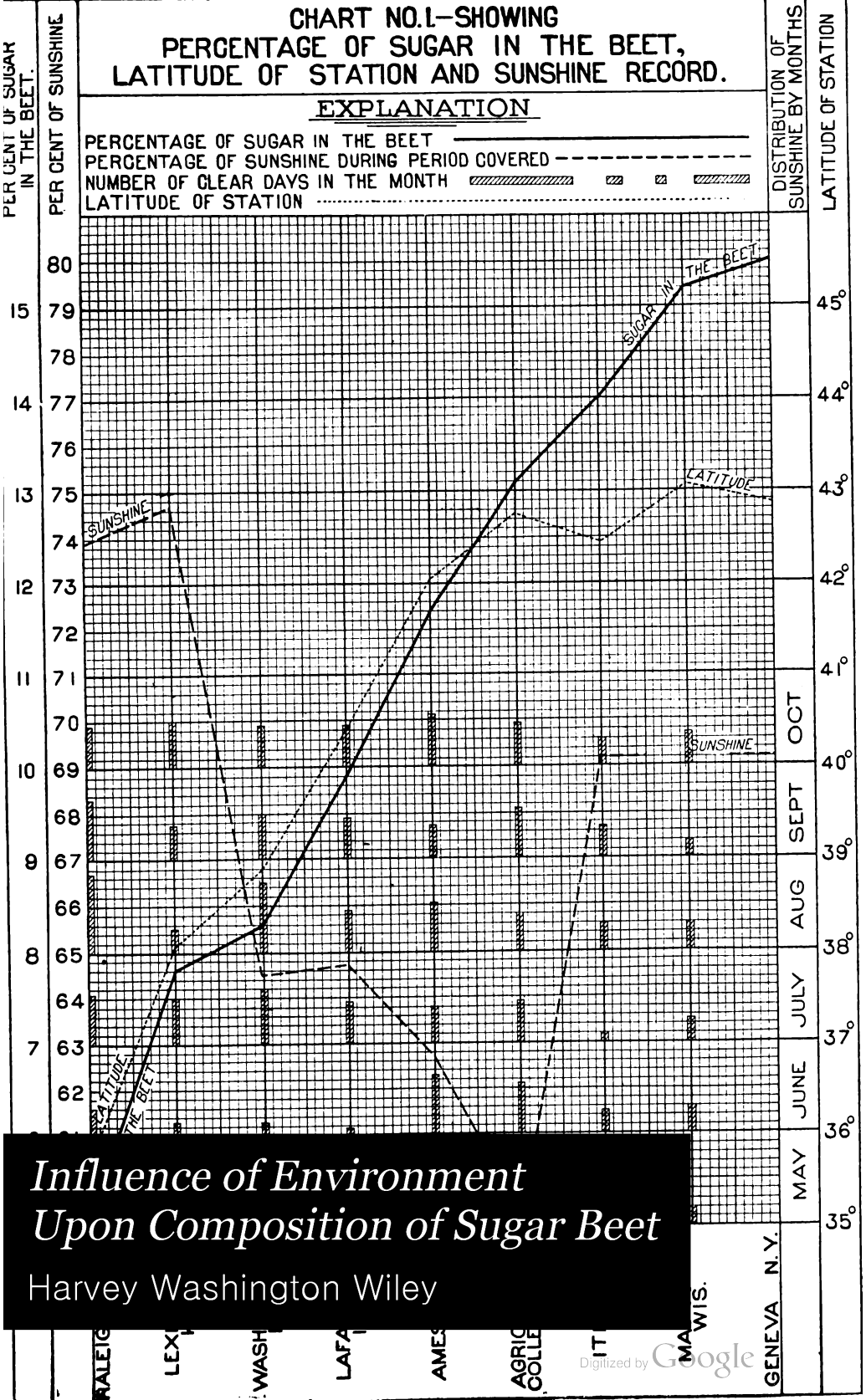

Influence of Environment Upon Composition of Sugar Beet

Harvey Washington Wiley

U. S. DEPARTMENT OF AGRICULTURE,
BUREAU OF CHEMISTRY—BULS. 64, 74, 78, 95, AND 96.
H. W. WILEY, *Chief.*

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BY

HARVEY W. WILEY,
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WITH DETAILS OF THE ANNUAL EXPERIMENTS AND A GENERAL SUMMARY OF THE FIVE-YEAR INVESTIGATION.

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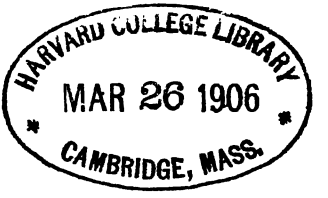

BULLETIN No. 64.

U. S. DEPARTMENT OF AGRICULTURE.
BUREAU OF CHEMISTRY.

THE INFLUENCE OF ENVIRONMENT

UPON THE

COMPOSITION OF THE SUGAR BEET, 1900.

BY

HARVEY W. WILEY,
CHIEF OF BUREAU,

IN COLLABORATION WITH THE WEATHER BUREAU AND THE AGRICULTURAL EXPERIMENT STATIONS OF INDIANA, IOWA, KENTUCKY, MICHIGAN, NEW YORK, CORNELL UNIVERSITY, NORTH CAROLINA, UTAH, AND WISCONSIN.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1901.

LETTER OF TRANSMITTAL.

U. S. DEPARTMENT OF AGRICULTURE,
BUREAU OF CHEMISTRY,
Washington, D. C., July 30, 1901.

SIR: I have the honor to submit herewith for your inspection and approval manuscript and graphic charts showing the results of the study by the Division of Chemistry, in collaboration with a number of the experiment stations and with the Weather Bureau, of effect of environment upon the chemical composition of the sugar beet. I recommend that this manuscript be printed as Bulletin No. 64, Bureau of Chemistry.

Respectfully,

H. W. WILEY, *Chief of Bureau.*

Hon. JAMES WILSON, *Secretary.*

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THE INFLUENCE OF ENVIRONMENT UPON THE COMPOSITION OF THE SUGAR BEET, 1900.

ORGANIZATION OF COLLABORATIVE WORK.

For more than a quarter of a century the Division of Chemistry of the Department of Agriculture has been studying the effect of environment upon the composition of the sugar beet in so far as its content of sugar is concerned. The present bulletin will be devoted principally to the study of climatic influences, reserving for future monographs the rôles played by the soil and applied fertilizers.

The early studies of this division emphasized the fact, already pointed out by European investigators, that beets grown in more northern latitudes show a higher content of sugar than when grown farther south. So strongly were these facts brought out by our own investigations that it was deemed advisable to limit, or at least suggest the limitation of, the growth of the sugar beet for commercial purposes to the more northern portions of our country. When, later on, the development of the arid regions showed the possibility of the production of beets of high grade, a totally different problem was presented for consideration—a problem which had never been entered upon by investigators of agricultural science. It is evident that the factors which are dominant in irrigated areas are very different from those which determine the character of the product in areas where the rainfall is usually sufficient for the production of the crop. In the present bulletin our studies have been confined to the usual climatic conditions prevalent throughout the greater part of the United States devoted to agriculture. In order, however, to include at least some idea of the nature of the problem in irrigated regions, one station, namely, that of Utah, was invited to collaborate in the work. The Bureau[1] is greatly indebted to the directors of the agricultural experiment stations who consented to collaborate in the work, not only for the heartiness and value of their cooperation, but especially for the reason that this collaboration was given without adequate compensation. Inasmuch as the funds available for the investigation were very limited and scarcely more than sufficient to conduct the chemical work at the Department

[1] On July 1, 1901, the Division of Chemistry became a Bureau.

of Agriculture, it would have been impossible to have carried on the work without the generosity of the collaborating stations. The following agricultural stations were invited to cooperate in the work and all accepted, namely: Indiana, Iowa, Kentucky, Michigan, New York, North Carolina, Utah, and Wisconsin. In New York both the State station at Geneva and the Cornell station at Ithaca were invited to collaborate.

The following letters were sent to the directors of the several stations named on April 4 and 17, 1900:

APRIL 4, 1900.

DEAR SIR: I have just received from Mr. Maurus Deutsch, one of the progressive sugar-beet seed growers of Austria, a small quantity of the very highest grade of sugar-beet seed, of three different varieties of the Austrian Kleinwanzlebener. I should like very much to have this seed planted with the greatest care, cultivated in the highest style of the art, and analyzed at the period of full maturity.

If you can use a small quantity of this seed, say enough to plant an eighth or a fourth of an acre, I shall be very glad to send it on to you, together with a full description of the names, etc.

Please let me hear from you at your earliest convenience in regard to this matter.

Very truly, yours,

H. W. WILEY, *Chemist.*

APRIL 17, 1900.

DEAR SIR: I take pleasure in sending by separate mail the high-grade Austrian beet seed of which I wrote you a short time ago.

The purpose I have in view in asking your collaboration in this matter is to make a careful study of the influence of climate on the character of the beets grown. To this end the seed has been distributed over a wide range of meteorological conditions, and the result of the study will be of the greatest interest.

For this reason I have requested your aid, and would ask you to take every possible care in the growth of these beets. I especially want the seed planted in sufficient quantities to insure a perfect stand. These seeds have not been tested by the division here, because I did not want to wait until that was done, and therefore I would ask you to plant them at the rate of at least 30 pounds per acre, under the most favorable conditions possible. I would also ask you to attend carefully to the cultivation of the beets, and to keep a record of the cultivation data and the meteorological conditions which prevail during the growing season.

For analytical purposes I would be glad if you would send here, from time to time, representative samples of the beets. Mailing facilities will of course be granted you for this purpose. If you have not already the use of the frank of the Department for this purpose, please inform me at the time of harvest and I will send special franks for the transmission of samples through the mails, and also the directions for securing the representative samples desired.

I would like also to have the analyses made at your own laboratory, if you have time to do so.

I thank you most heartily for your consent to enter into this collaborative work, which I trust may prove of advantage to your station.

Very truly, yours,

H. W. WILEY, *Chemist.*

To each of the stations collaborating the requisite quantity of the Austrian Special Kleinwanzlebener beet seed was sent. There was no special reason for the selection of this particular variety of seed other than that it was produced from mother beets which had been selected by analysis on account of their high sugar content. The tendency of such seeds would therefore be to produce beets of uniformly high grade. It is evident that any variation in the quality of the beets grown in different localities from the same seed must be due to the environment, namely, soil, fertilization, culture, and meteorological conditions.

EXPERIMENTS CONDUCTED AT WASHINGTON, D. C.

A plot on the agricultural farm situated on an island, or reclaimed lands, of the Potomac River, lying south of Aqueduct Bridge, was also planted with the Austrian Special Kleinwanzlebener beet seed and subjected to the ordinary careful cultivation necessary for the production of high-grade beets. These lands, being sufficiently fertile, received no fertilizer of any kind. The soil was formed of débris taken from the Potomac River by dredging machines, and therefore it has no geological characteristics. It is a mixture of silt, sand, and organic matter, readily yielding to tillage and forming a fine seed bed. It was prepared by deep plowing, harrowing, and reducing the surface to fine tilth. The roots produced by a previous year's growth when not in cultivation were carefully removed from the soil. The physical condition of the soil at the time of planting was all that could be desired, and the growth of the beets was uniform and luxuriant. The beets were planted on May 5, and thinned to nearly the proper stand about June 15, the thinning being completed about one month later. They were cultivated once a week until July 15. The meteorological data for Washington for the period of growth is as follows:

Meteorological data for Washington, D. C., from May to October, 1900.

Month.	Mean temperature.	Precipitation.	Sunshine.			Clear days.	Cloudy days.
			Actual.	Possible.	Per cent.		
	Degrees.	*Inches.*	*Hours.*	*Hours.*			
May	64.4	4.02	258.0	443.8	58	17	9
June	72.2	10.94	244.1	445.9	55	11	9
July	78.7	1.25	351.6	453.0	78	18	5
Total	71.8	16.21	.....	.....	63.7	46	23
August	79.6	2.28	334.7	423.2	79	22	5
September	73.6	4.61	254.6	373.4	68	15	6
October	61.6	1.44	168.7	346.0	49	13	14
Total	71.6	8.33	.....	.....	65.3	50	25
Sum total	71.7	24.54	.....	.....	64.50	96	48

The dates of securing samples, the weight of samples obtained, the estimated yield in tons per acre, average weight of the beets har-

Two analyses were made of the beets grown by J. M. Wilson at North Judson, giving the following results:

Field data and analyses for Austrian Special Kleinwanzlebener grown at North Judson, Ind.

No.	Date of planting.	Date of harvest.	Average weight.	Sugar in juice.	Sugar in beet.	Purity.
			Ounces.	*Per cent.*	*Per cent.*	
1	May 26	Oct. 1	17.5	13.7	13.0	86.0
2	May 26	Oct. 24	12.9	15.1	14.3	93.0

The only meteorological data obtainable for North Judson are those for South Bend, as given below, and as no regular station, either agricultural or meteorological, exists at these points, the results for North Judson have not been included in the data platted on the charts.

Meteorological data for North Judson,[1] Ind., from May to October, 1900.

Month.	Mean temperature.	Precipitation.
	Degrees.	*Inches.*
May	62.9	1.74
June	69.0	2.66
July	72.6	5.81
Total	68.2	10.21
August	76.4	6.43
September	67.4	2.25
October	61.4	1.31
Total	68.4	9.99
Sum total	68.3	20.20

[1] Data given is for South Bend, 40 miles northeast of North Judson. For sunshine record see Lafayette, 58 miles south, and Indianapolis, about 100 miles south, of North Judson.

In transmitting the above meteorological data Mr. Huston, under date of March 27, 1901, makes the following comments:

I inclose the weather record for Lafayette and for South Bend. We have no observer at North Judson, but South Bend is up the valley a little ways, and is practically on the same isotherm. You will notice that the season was quite abnormal at both places, and especially is this true of part of the season during which time the beets ought to ripen; and the number of cloudy days is unusually high. While the rainfall during September and October in the northern part of the State is somewhat below normal, the excessively high temperature in October, together with the fact that nearly all of the rainfall occurred on October 6 and 7, which furnished plenty of water to keep the beets growing, made the ripening period even less favorable than the record would seem to indicate.

It will be observed that the beets grown at North Judson, although somewhat small, were of fair sugar content and of high purity. The beets grown at the experiment station farm were phenomenally small and contained a low percentage of sugar, but a purity slightly above the minimum standard desirable for manufacturing purposes. It is remarkable to see so great a difference in the composition of beets grown in the same State and in localities less than 100 miles apart. North Judson is almost exactly north of Lafayette, and its proximity to Lake Michigan doubtless accounts for the differences in the meteorological environment of the two places. The experience of former

years in the same localities shows that Starke County, in which North Judson is situated, is favorably located for the production of beets of high grade.

EXPERIMENTS CONDUCTED BY THE IOWA STATION.

The sample of Austrian Special Kleinwanzlebener was planted on May 29 in rows 16 inches apart, and thinned on June 20. The plat received the usual careful cultivation. The assistant in agriculture at the Iowa station at Ames, Mr. Atkinson, gives the following description of the soil on which the experiments were made:

The soil upon which the Austrian Special Kleinwanzlebener were grown was an upland prairie. It was a clover sod in 1898; in 1899 it grew a crop of spring wheat, while the beets were grown on it in 1900. It has been several years since it received an application of manure.

The samples were harvested on November 6, and eight beets were sent to the Department of Agriculture, and were analyzed on November 12 with the following results:

Average weight	ounces	13
Sugar in the beet	per cent	11.7
Purity		76.9

The season was not considered a favorable one for beet culture. The climatic conditions prevailing during the growing season are shown in the accompanying tables:

Meteorological data for Ames, Iowa,[1] from May to October, 1900.

Month.	Mean temperature.	Precipitation.	Clear days.	Cloudy days.
	Degrees.	*Inches.*		
May	64.4	4.36	14	5
June	69.4	6.48	19	1
July	73.0	9.14	12	0
Total	68.9	19.98	45	6
August	76.8	5.46	16	0
September	66.0	7.12	11	1
October	59.8	3.73	17	4
Total	67.5	16.31	44	5
Sum total	68.2	36.29	89	11

[1] For sunshine record see table for Des Moines, that being the nearest station at which a sunshine record was kept.

Meteorological data for Des Moines, Iowa,[1] from May to October, 1900.

Month.	Mean temperature.	Precipitation.	Sunshine.			Clear days.	Cloudy days.
			Actual.	Possible.	Per cent.		
	Degrees.	*Inches.*	*Hours.*	*Hours.*			
May	64.2	4.76	274.6	451.9	61.0	9	6
June	70.1	4.89	339.3	456.2	74.0	12	2
July	74.2	5.15	300.1	461.8	65.0	11	5
Total	69.5	14.80	.....	.....	66.7	32	13
August	77.7	8.02	278.8	429.4	65.0	11	4
September	65.4	3.66	203.1	374.5	54.0	10	12
October	60.4	3.08	195.7	342.5	57.0	10	9
Total	67.8	14.76	.....	.....	58.7	31	25
Sum total	68.65	29.56	.....	.....	62.7	63	38

[1] Thirty miles south of Ames.

EXPERIMENTS CONDUCTED BY THE KENTUCKY STATION.

The Austrian Special Kleinwanzlebener was planted April 25 in rows 18 inches apart, and was thinned May 22. The soil was a rich loam, and the estimated yield per acre was 10 tons. The season was reported as being favorable, the climatic conditions for the period of growth having been as follows:

Meteorological data for Lexington, Ky., from May to October, 1900.

Month.	Mean temperature.	Precipitation.	Sunshine.			Clear days.	Cloudy days.
			Actual.	Possible.	Per cent.		
	Degrees.	*Inches.*	*Hours.*	*Hours.*			
May	65.6	3.54	297.6	441.7	67.00	15	7
June	72.5	2.19	291.6	443.1	66.00	4	7
July	77.0	2.80	358.4	450.1	80.00	15	3
Total	71.7	8.53	.....	.....	71.00	34	17
August	79.3	5.75	361.8	422.1	87.00	8	2
September	73.2	1.85	292.1	373.0	78.00	11	4
October	64.9	.79	243.5	347.3	70.00	15	5
Total	72.5	8.39	.....	.....	78.30	34	11
Sum total	72.1	16.92	.....	.....	74.65	68	28

The analyses were commenced by the station on August 30, and continued at intervals until October 16. After that time the analyses were suspended until November 19, when an additional sample was examined, nine series of analyses having been made altogether.

The results of these analyses were as follows.

Station analyses of Austrian Special Kleinwanzlebener grown at Lexington, Ky.

Date of sampling.	Number of beets taken.	Weight topped.	Weight trimmed.	Brix.	Sugar by polarization.	Sugar in beet.	Purity.
1900.		*Ounces.*	*Ounces.*	*Degrees.*	*Per cent.*	*Per cent.*	
August 30	2	11¼	8	12.7	10.05	9.6	79.20
September 19	1	20¾	15½	11.2	8.40	8.0	74.10
Do	1	13½	10	10.0	7.00	6.6	70.00
September 26	2	8¾	5¾	10.2	6.85	6.6	67.72
October 6	1	14¾	11	13.3	9.90	9.4	74.40
Do	1	9¼	6¾	11.9	8.50	8.1	72.20
October 12	1	12¼	7½	10.7	7.35	7.0	68.70
October 16	1	10¼	8¼	11.9	8.05	7.7	67.60
November 19	.....	10¼	8¼	13.7	7.00	6.6	65.20
Average	.....	12.47	9	11.73	8.12	7.7	71.01

A sample of these beets was sent to the Department of Agriculture for analysis on November 19. In forwarding this sample Dr. Peter, chemist of the station, calls attention to the fact that his analyses show that the beets deteriorated greatly after August. The data obtained by the analysis of the sample sent to the Department of Agriculture were as follows:

Average weight of the beets	ounces..	9
Percentage of sugar in the beets	per cent..	7.9
Purity		68.0

The data show that in the analysis of these samples at the Department of Agriculture a somewhat higher percentage of sugar, of a slightly increased purity, was obtained than that given for the samples taken on the same date, November 19, and analyzed at the Kentucky station. A part of the increase in sugar may be ascribed to the drying out of the samples in transit.

EXPERIMENTS CONDUCTED BY THE MICHIGAN STATION.

A field of sandy loam, selected for this experiment, was subsoiled about ten days before sowing the beet seed, and the surface of the field reduced to a proper degree of tilth. The seeding was done on April 28, 1900, and the beets received the usual cultivation to keep the surface of the soil loose and free from weeds.

The agriculturist of the station, Mr. B. D. Towar, reports:

We are very well pleased with the results, as the ground was by no means the most desirable for growing beets. A good season has been favorable to Michigan beets and satisfactory reports are coming from all directions.

The meteorological conditions are shown by the following data:

Meteorological data for Agricultural College, Mich.,[1] from May to October, 1900.

Month.	Mean temperature.	Precipitation.	Clear days.	Cloudy days.
	Degrees.	*Inches.*		
May	58.8	4.17	10	9
June	65.2	2.57	16	6
July	69.6	4.15	13	6
Total	64.5	10.89	39	21
August	73.3	2.98	12	3
September	63.2	.89	16	8
October	56.6	2.77	14	8
Total	64.4	6.64	42	19
Sum total	64.45	17.53	81	40

[1] For sunshine record see table for Detroit, the nearest station at which this record is kept.

Meteorological data for Detroit, Mich.,[1] from May to October, 1900.

Month.	Mean temperature.	Precipitation.	Sunshine.			Clear days.	Cloudy days.
			Actual.	Possible.	Per cent.		
	Degrees.	*Inches.*	*Hours.*	*Hours.*			
May	60.0	3.08	246.5	451.9	55	6	13
June	66.6	3.99	310.6	456.2	68	12	6
July	72.0	3.71	267.6	461.8	58	9	7
Total	66.2	10.78	.....	.....	60.3	27	26
August	75.5	2.08	263.3	429.4	61	12	7
September	66.8	1.88	215.2	374.5	57	10	5
October	60.0	2.85	191.0	342.5	56	12	6
Total	67.4	6.81	.....	.....	58	34	18
Sum total	66.8	17.59	.....	.....	59.15	61	44

[1] Seventy-six miles southeast of Agricultural College.

Analytical data obtained with the Austrian Special Kleinwanzlebener at the Michigan station.

Number of sample.	Seed test from 100 seed bulbs.			Average distance apart in row.	Yield per acre.	Average weight samples analyzed.	Per cent of sugar in juice.	Per cent of sugar in beet.	Purity.
	Number of sprouts at the end of one week.	Number of sprouts at the end of two weeks.	Seed balls that did not grow.						
				Inches.	*Tons.*	*Pounds.*			
1	122	150	30	6+	15.21	12	13.61	12.9	79.27
2	155	175	25	6—	16.29	12	14.03	13.3	80.77
Total					31.50	24	27.64	26.2	160.04
Average					15.75	12	13.82	13.1	80.02

EXPERIMENTS CONDUCTED BY THE NEW YORK STATION AT GENEVA.

The report of the collaborative work done at the Geneva station was made by the agriculturist, Mr. G. W. Churchill, under date of December 7, 1900. Twelve different plots of beets were grown, of which numbers 3, 6, 9, 12, and 13 were of the Austrian Special Kleinwanzlebener. Plot No. 13 was composed of check rows planted between plots which were fertilized with different materials in order that there should be no extension of the effect of the fertilizers from one plot to another. Under date of December 19 Director Jordan, of the station, made the following report:

For three years we have been making an effort to compare the effect of commercial fertilizers with that of farm manures upon the composition of sugar beets. In all of these years the percentage of sugar and the coefficient of purity with the beets raised on the farm manure have been of a high standard, the percentage of sugar in two years being higher than where the beets received commercial fertilizers. The other year the percentage of sugar was higher in the beets fertilized with farm manure than where no farm manure at all was used. The amount of manure per acre was 40,000 pounds, or about 10 cords. It was manure from the cow stable which had been somewhat fermented but not very fully. In other years we have used fresh manure. I am now working up the results for the three years to publish in a bulletin. I am inclined to think that we have all the time been placing altogether too much confidence in German results as applied to American conditions.

The following table gives the mean temperatures and precipitations for Lyons, 13 miles north of Geneva, during the growing season, the sunshine data not being obtainable for this or any other station nearer than Ithaca, for which place a full set of data may be found further on.

Meteorological data for Lyons, N. Y., from May to October, 1900.

Month.	Mean temperature.	Precipitation.
	Degrees.	*Inches.*
May	58.4	1.85
June	67.9	2.74
July	72.4	3.46
Total	66.2	8.05
August	73.8	2.49
September	67.1	2.01
October	58.6	3.71
Total	66.5	8.21
Sum total	66.4	16.26

The samples sent to us by the Geneva station were analyzed in the Division of Chemistry, and the results obtained with the Austrian Special Kleinwanzlebener were as follows:

Department analysis of Austrian Special Kleinwanzlebener beets grown at Geneva, N. Y.

Number.	Weight.	Sugar in juice.	Sugar in beet.	Purity.
	Pounds.	*Per cent.*	*Per cent.*	
1	17	15.2	14.4	82.2
2	17	16.0	15.2	83.8
3	17	16.4	15.6	82.8
4	16	16.1	15.3	84.3
5	17	15.2	14.4	82.2
Average	16.8	15.78	14.98	83.06

In the above data the samples represented by Nos. 1 and 2 were grown under a heavy fertilization of superphosphate. Nos. 3 and 4, corresponding to Nos. 9 and 12 referred to above, were grown under fertilization with farmyard manure, and No. 5, corresponding to No. 13, represents the check rows planted between the fertilized plots.

A complete study of the sugar content of the beets grown at the Geneva station was made at that place between the dates of November 23 and December 6. The results of these determinations are given in the following table:

Austrian Special Kleinwanzlebener beets.

[Grown and analyzed at the New York Experiment Station, Geneva, N. Y.]

Date of analysis.	Number of plat.	Number of beets used for analysis.	Degree Brix.	Average weight of beets (without tops).	Sugar in juice.	Sugar in beet.	Coefficient of purity.
1900.				*Pounds.*	*Per cent.*	*Per cent.*	
November 23	8	20	19.8	0.97	16.8	16.0	84.8
November 24	8	20	20.7	.965	17.6	16.7	85.2
November 23	9	20	18.8	.95	15.7	14.9	83.7
November 24	9	20	18.6	1.00	15.7	14.9	84.3
November 23	10	20	19.4	.82	16.6	15.8	85.4
December 1	10	20	19.7	.89	17.1	16.3	87.0
November 23[1]	11	20	22.1	.79	18.5	17.6	84.0
December 4	11	20	20.9	.91	17.5	16.6	83.9
November 23	12	20	19.0	1.63	16.1	15.3	84.7
December 1[1]	12	20	18.9	.89	16.1	15.3	85.3
December 4	Check.	20	20.9	.76	17.5	16.6	83.6
December 6	Check.	12	19.0	.88	16.2	15.4	85.1
Average			19.8	[2].95	16.8	16.0	84.8

[1] Beets somewhat wilted.

[2] Equivalent to 15.2 ounces.

EXPERIMENTS CONDUCTED BY THE NEW YORK STATION AT ITHACA.

Director I. P. Roberts, of the Ithaca station, reported under date of March 11, 1901, that the Austrian Special Kleinwanzlebener beet seed for the collaborative experiments had been planted on May 17, 1900, in rows 20 inches apart, and harvested on October 26. The soil was a sandy loam in a good state of fertility. The record of the climatic conditions during the growing season is as follows:

Meteorological data for Ithaca, N. Y., for May to October, 1900.

Month.	Mean temperature.	Precipitation.	Sunshine.			Clear days.	Cloudy days.
			Actual.	Possible.	Per cent.		
	Degrees.	*Inches.*	*Hours.*	*Hours.*			
May	57.1	1.51	281.9	451.9	62	11	15
June	67.0	1.98	242.1	456.2	75	7	12
July	72.0	2.41	332.1	461.8	72	3	11
Total	65.4	5.90	314.8	429.4	69.7	21	38
August	72.3	2.93	260.4	374.5	73	9	8
September	64.9	.94	216.0	342.5	70	11	9
October	57.2	4.06	.....	.....	63	9	13
Total	64.8	7.93	.....	.....	68.7	29	30
Sum total	65.1	13.83	.....	.....	69.2	50	68

The analytical data obtained at the station on the beets raised were as follows:

Average weight of beets analyzed	ounces	18
Yield per acre	tons	15
Sugar in the juice	per cent	14.8
Sugar in the beet	do	14.0
Coefficient of purity		81.9

EXPERIMENTS CONDUCTED BY THE NORTH CAROLINA STATION.

The seed of the Austrian Special Kleinwanzlebener were planted on May 22, the date of thinning was June 15, and the date of harvesting November 1. The soil was a sandy loam, and the width between the rows 36 inches. The season was rather dry and to that extent unfavorable. The estimated yield per acre was 1¼ tons.

Samples of the beets were forwarded to this Department from Raleigh on November 21. They were, however, in such a poor condition when received that they were deemed worthless for analytical purposes and the analytical data are confined therefore to the analyses made at the station at Raleigh. The figures obtained are as follows:

Average weight of beets	ounces	12.4
Average sugar in the beets	per cent	5.2

The above data show that the beets were remarkably poor even for the locality. While it was not expected that they would show a

high quantity of sucrose, it is evident that under other conditions or in other seasons a much better result could be obtained. The following table shows the meteorological conditions under which these beets were grown:

Meteorological data for Raleigh, N. C., from May to October, 1900.

Month.	Mean temperature.	Precipitation.	Sunshine.			Clear days.	Cloudy days.
			Actual.	Possible.	Per cent.		
	Degrees.	*Inches.*	*Hours.*	*Hours.*			
May	69	3.12	335.1	436.1	77	16	3
June	76	8.47	284.9	437.2	65	9	7
July	80.9	5.53	313.5	444.3	71	16	4
Total	75.3	17.12	.....	.....	71	41	14
August	82.2	4.51	357.4	418.7	85	25	1
September	75.8	2.13	316.5	372.2	85	20	1
October	65.6	1.04	208	348.9	60	14	8
Total	74.5	7.68	.....	.....	76.7	59	10
Sum total	74.9	24.80	.....	.....	73.9	100	24

EXPERIMENTS CONDUCTED BY THE UTAH STATION.

The data from the Utah Agricultural Experiment Station are included in this report not so much for the purpose of direct comparison as to show the influence of irrigation upon the yield and character of the beets. It is evident that the artificial conditions which obtain in irrigated regions are so different from those that naturally exist as to render of doubtful value a comparison between the two sets of data, and hence the results in Utah have not been included in the graphic charts. It is proposed at some future time to make an additional study in irrigated regions of the influences of sunshine and the differences of latitude on the character of the beets grown under irrigation. Nevertheless there will be some interest attached to the utilization of the data from Utah in the present comparison.

The beets were planted on May 8, the date of thinning was June 7, the dates of irrigation, June 22, July 14 and 28, August 11, and September 1; the dates of cultivation were June 20 and 25, July 16, August 2 and 14; the dates of harvesting were October 24, 25, and 27.

The yield per acre and the analytical results as determined at the Logan station are as follows:

Estimated yield per acre	tons	18.9
Percentage of sugar in the beet	per cent	12.1
Purity coefficient		84.2

The climatic conditions under which these beets were grown are shown in the following tables of data for Logan and Salt Lake City, Utah:

Meteorological data for Logan, Utah,[1] from May to October, 1900.

Month.	Mean temperature.	Precipitation.	Clear days.[2]	Cloudy days.[2]
	Degrees.	*Inches.*		
May	57.4	1.42	17	11
June	70.4	.19	25	3
July	70.9	.51	26	3
Total	66.2	2.12	68	17
August	69.4	.71	24	3
September	59.9	.94	20	6
October	49.8	2.38	26	2
Total	59.7	4.03	70	11
Sum total	62.95	6.15	138	28

[1] For sunshine data see table for Salt Lake City, the nearest point at which this record was kept.
[2] These figures are for Corinne, 19 miles southwest of Logan.

Meteorological data for Salt Lake City, Utah,[1] from May to October, 1900.

Month.	Mean temperature.	Precipitation.	Sunshine.			Clear days.	Cloudy days.
			Actual.	Possible.	Per cent.		
	Degrees.	*Inches.*	*Hours.*	*Hours.*			
May	60.6	0.44	356.5	449.1	79	24	3
June	73.8	.08	414.1	451.9	92	28	0
July	74.7	.32	430.5	458.6	94	26	0
Total	69.7	.84	.....	.....	88.3	78	3
August	74	.72	357.6	427.4	84	23	0
September	62.7	1.44	288.8	374.	77	18	1
October	52.6	1.99	208.8	343.9	61	17	10
Total	63.1	4.15	.....	.....	74	58	11
Sum total	66.4	4.99	.....	.....	81.2	136	14

[1] Sixty-six miles south of Logan.

DISCUSSION OF IRRIGATION EXPERIMENTS.

The director of the station, Mr. John Widtsoe, under date of November 17, makes the following comments on the season's work:

The sugar content * * * is much lower than the average of the beets grown at the station in the previous years. The beets grown in the irrigation experiments have this season contained from 15 to 18 per cent of sugar. The above varieties were treated as nearly as possible the same as the average beet grower of Utah treats his crop. It is difficult to account for the low per cent of sugar, though I am led to believe from the experiments carried on at the station that the amount of water used and the time of its application has a great influence on the composition of the beet.

It is evident from the various experiments in irrigation previously conducted that an elaborate series of comparative studies should be made to determine, first, the amount of water necessary to produce the maximum weight of crop and content of sugar, and second, the

most favorable periods of its application. It is doubtful whether it is advisable to apply an abundant quantity of water to a beet field as late as September 1, as was the case in the above experiments. The tendency in this case would be to keep the beets growing too long, or perhaps to start a second growth, which would consume much of the sugar already stored.

Another point in connection with the irrigation work should be prominently kept in mind, viz, that the injurious effects of high temperatures as shown in the inferior content of sugar in beets grown far south of the natural habitat may be due rather to premature ripening and the rapid evaporation of water than to the effect of temperature directly. It is difficult to understand how the rise of a few degrees of temperature could so seriously affect the sugar content of the beet simply by reason of increased amount of heat. To me it seems more probable that the deleterious influences of a high temperature are of an indirect rather than a direct nature.

EXPERIMENTS CONDUCTED BY THE WISCONSIN STATION.

CULTURAL DATA.

The field notes in regard to the cultivation of the Austrian Special Kleinwanzlebener beet seed, furnished by Mr. Roscoe H. Shaw, acting chemist of the Madison station, under date of November 7, 1900, are as follows:

The field set apart for sugar-beet work at the Wisconsin experiment station this season was a plat of clay loam consisting of half an acre. This plat had been used for the sugar-beet work in 1898 and for variety tests in 1899. The field was not manured on the northern half in 1898, and not at all in 1899.

The plat was divided into quarters, the middle half receiving a mixed fertilizer consisting of 90 pounds of Star phosphate (dissolved bone), 90 pounds of sulphate of potassium, and 100 pounds of nitrate of soda. The phosphate was put on first and the potash and half of the nitrate mixed and distributed next. The northern quarter and southern quarter were left unfertilized. The field was disked north and south and then dragged with pulverizer east and west. Eight varieties of beet seed were planted, all of which were received from the Department of Agriculture. The field was planted on May 15. A heavy shower, followed by six days of dry weather, caused the plat to bake so hard that with the exception of the section devoted to Zehringen (Strandes, Germany), of which there was no seed left, it was reharrowed and replanted. From this circumstance, owing to lack of seed, but seven rows of the Austrian Special Kleinwanzlebener were planted; these rows were made 15 inches apart. The second planting was finished May 21.

May 26.—The section not replanted was cultivated with garden wheel hoe. At this time the crust was very hard and beet plants were coming up in spots.

May 31.—No rain to this date and surface of ground was dried out, but beet sprout up in rows.

June 1.—A good rain fell for about an hour.

June 2.—Whole plat cultivated with wheel hoe.

June 4.—Beet plants well up; 1 to 2 inches high.

June 11.—The work of thinning beets was begun. They were thinned so as to

have one strong plant every 8 or 9 inches in the row. At this date the Austrian Special Kleinwanzlebener was rather behind the other varieties in development.

June 19.—The remaining 50 pounds of nitrate, mixed with twice the amount or more of dirt from the field, was sown on the fertilized part.

June 24.—No difference was noticeable between different varieties or between the fertilized or unfertilized parts.

August 4.—Fertilized half of field seemed to be in better condition than the unfertilized.

August 18.—No apparent difference was noticeable between varieties.

October 13.—The beets were harvested; they were rather smaller than average beets and all of the varieties were of comparatively uniform size.

The section of the field devoted exclusively to the Austrian Special Kleinwanzelbener was 192 feet long by 8.75 feet wide, containing 1,680 square feet.

In harvesting beets 50-pound samples from each of the three sections of each variety were taken. In these samples the percentage of shrinkage was determined, and a subsample selected for the sugar determination.

Austrian Special Kleinwanzlebener beets grown and analyzed at the Wisconsin Experiment Station, Madison, Wis.

	Fertilized.	Unfertilized.
Average weight ..... pounds..	0.81	0.73
Shrinkage[1] ..... per cent..	18.98	19.07
Specific gravity	1.0779	1.0753
Sugar in the juice ..... per cent..	16.66	15.28
Purity	88.53	83.93
Sugar in the beet ..... per cent..	15.81	14.52
Total yield:		
Total weight ..... pounds..	841.6	542.9
Weight less shrinkage ..... do....	681.9	439.4
Sugar ..... do....	107.6	63.81

[1] The shrinkage refers to that part of the beet lost in washing and crowning.

Results calculated to the acre are as follows:

	Fertilized.	Unfertilized.
	Tons.	*Tons.*
Total weight	10.91	7.04
Weight less shrinkage	8.84	5.7
Sugar	1.398	0.83

It is interesting to note the influence of the fertilizer employed. The fertilized sections of the plat yielded almost 4 tons more per acre than the unfertilized, while the percentage of sugar in the fertilized portion was considerably higher than in the unfertilized. Since it would not be quite fair to select either the fertilized or the unfertilized data for purposes of comparison, it has been determined to take the mean of the two as representing the proper data for the comparative work.

The meteorological conditions under which these beets were grown are shown by the following table:

Meteorological data for Madison, Wis., from May to October, 1900.

Month.	Mean temperature.	Precipitation.	Clear days.	Cloudy days.
	Degrees.	*Inches.*		
May	60.6	1.86	6	14
June	67.7	3.20	9	7
July	70.2	6.91	8	14
Total	66.2	11.97	23	35
August	75.2	2.72	9	10
September	63.6	2.89	6	12
October	58.0	4.43	10	14
Total	65.6	10.04	25	36
Sum total	65.9	22.01	48	71

SUMMARY.

Summary of averages of analytical data, 1900.

	Weight.	Yield per acre.	Sugar in the beet.	Coefficient of purity.
	Ounces.	*Tons.*	*Per cent.*	
Raleigh, N. C	12.4	1.3	5.2	.....
Lexington, Ky.[1]	9.0	10.0	7.8	69.5
Washington, D. C	18.5	15.0	8.3	69.1
Lafayette, Ind	4.9	.....	9.9	83.0
Ames, Iowa	13.0	.....	11.7	76.9
Logan, Utah	.....	18.9	12.1	84.2
Agricultural College, Mich	12.0	15.8	13.1	80.0
North Judson, Ind	15.2	.....	13.7	89.5
Ithaca, N. Y	18.0	15.0	14.0	81.9
Madison, Wis.[2]	12.3	9.0	15.2	86.2
Geneva, N. Y.[3]	16.1	.....	15.5	83.9

[1] Average of data obtained at Washington and at Lexington.
[2] Average of data for fertilized and unfertilized plats.
[3] Average of data obtained at Washington and at Geneva.

Summary of meteorological data, May to October, 1900.

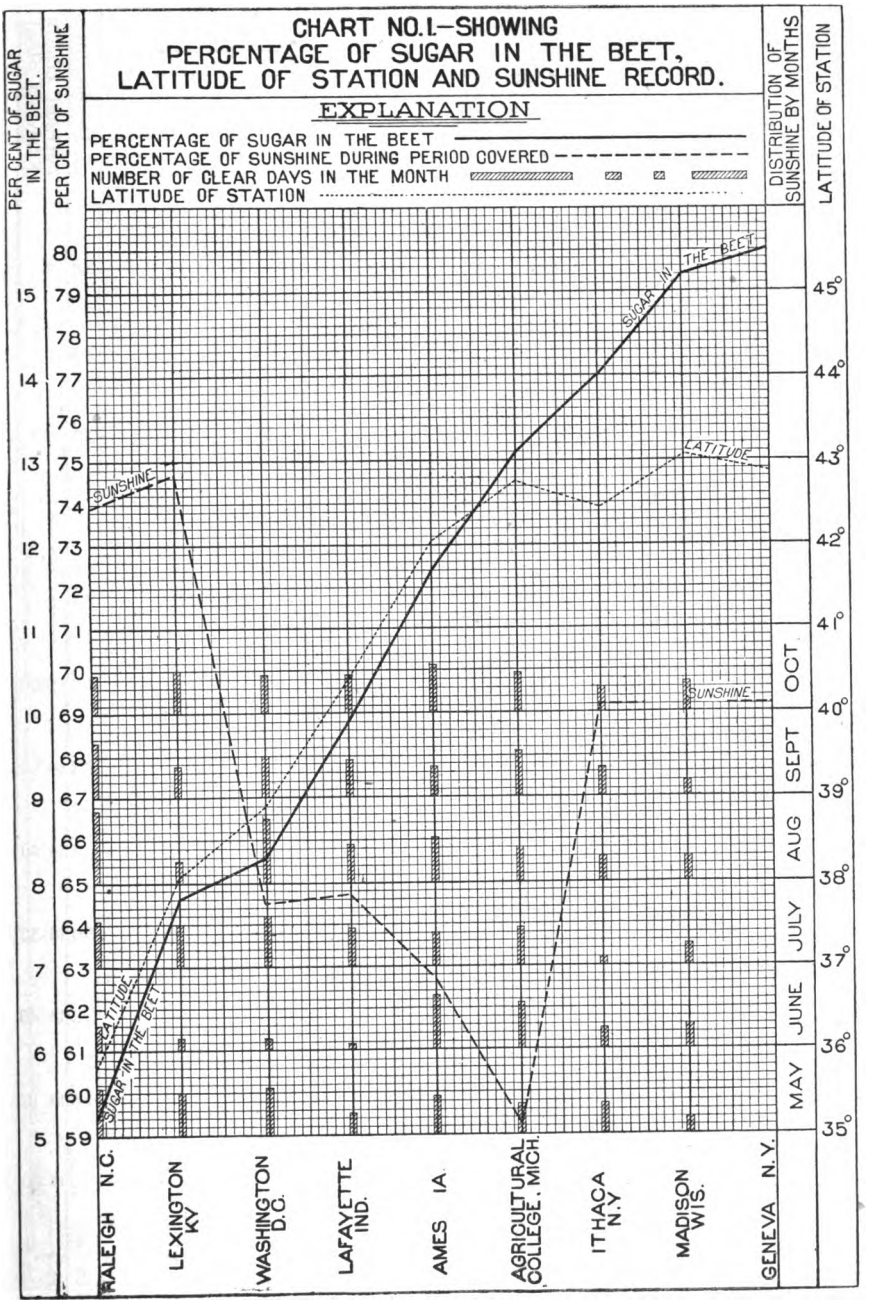
	Temperature.	Precipitation.	Clear days.	Cloudy days.	Sunshine.
	Degrees.	*Inches.*			*Per cent.*
Raleigh, N. C	74.9	24.8	100	24	73.9
Lexington, Ky	72.1	16.9	68	28	74.7
Washington, D. C	71.7	24.5	96	48	64.5
Lafayette, Ind.[1]	69.8	30.5	64	53	64.7
Ames, Iowa[2]	68.2	36.3	89	11	62.7
Logan, Utah[3]	63.0	6.2	138	28	81.2
Agricultural College, Mich.[4]	64.5	17.5	81	40	59.2
North Judson, Ind	68.3	20.2	(5)	(5)	(5)
Ithaca, N. Y	65.1	13.8	50	68	69.2
Madison, Wis	65.9	22.0	48	71	.....
Geneva, N. Y.[6]	66.4	16.3	(7)	(7)	(7)
	66.0	15.0	.....	.....	.....

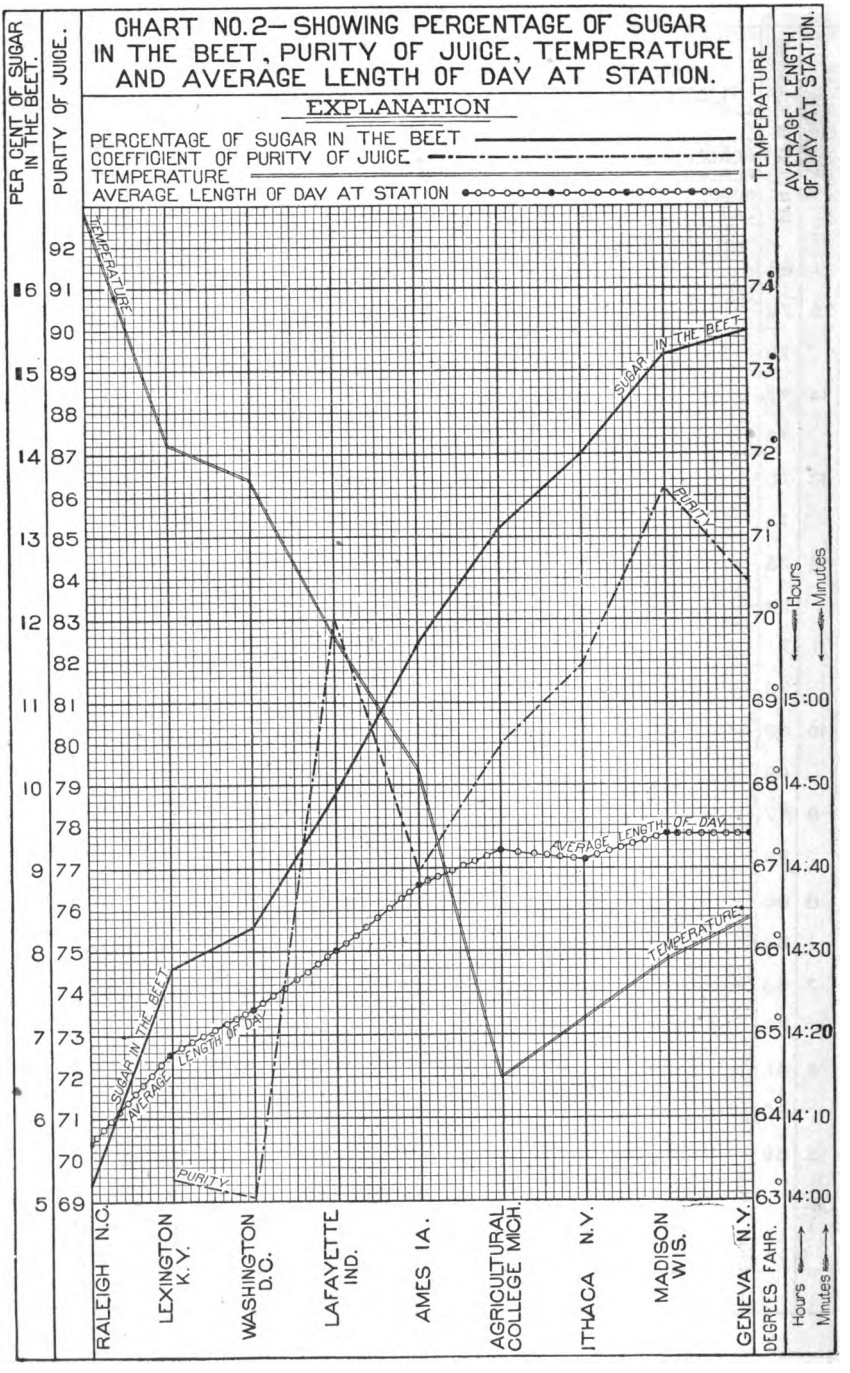
[1] Approximate data observed at Indianapolis.
[2] Approximate data observed at Des Moines.
[3] Approximate data observed at Salt Lake City.
[4] Approximate data observed at Detroit, Mich.
[5] See Lafayette.
[6] Data for Lyons, N. Y., used.
[7] See Ithaca.

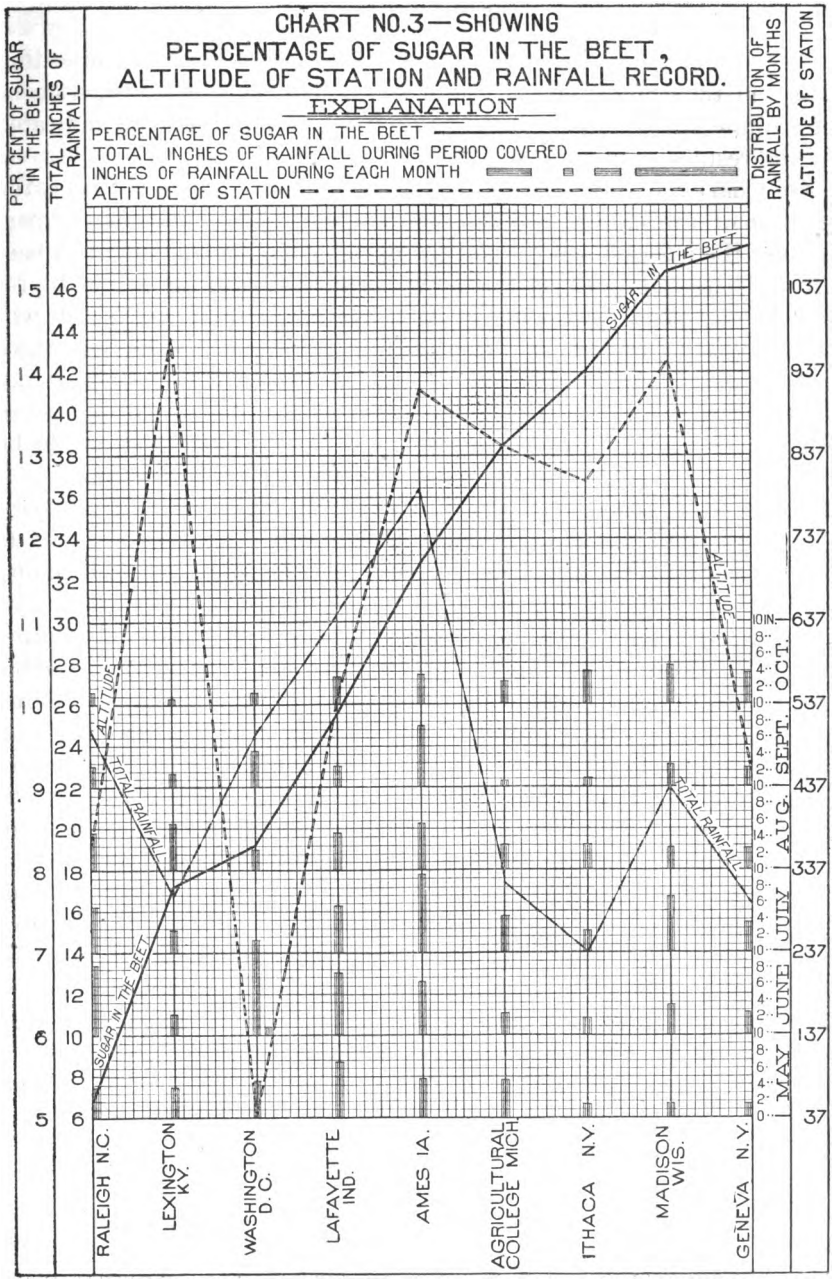
Summary of geodetic data for experiment stations.

	Average length of day.		Latitude.	Altitude.
	H.	*M.*	° ′ ″	*Feet.*
Raleigh, N. C	14	7	35 48 00	363
Lexington, Ky	14	18	38 02 25	979
Washington, D. C	14	23	38 53 23	37.5
Lafayette, Ind	14	30	40 23 00	542
Ames, Iowa	14	38	42 02 00	917
Logan, Utah	14	37	41 44 00	4,506
Agricultural College, Mich[1]	14	42	42 45 00	847
North Judson, Ind	14	34	41 11 00	695
Ithaca, N. Y	14	41	42 27 00	810
Madison, Wis	14	44	43 04 36	955
Geneva, N. Y	14	44	42 53 00	453

[1] Determinations for Lansing, Mich.







CONCLUSIONS.

The conclusions which are deduced from a study of the preceding data and the graphic charts, based as they are upon the observations of a single year, will be subject to such correction as may be indicated by the results of subsequent studies.

On Chart No. 1 are platted the percentage of sugar in the beet, the latitude of the station, and the hours of sunshine. The curve representing the latitude and the curve representing the sugar in the beet are evidently more nearly related to each other than the curves representing any other figures in any other one of the three charts. It will be seen that there is a very close agreement between the latitude curve and the percentage of sugar curve. High sugar and high latitude run very evenly together. The actual hours of sunshine do not appear to have much influence upon the sugar content, or perhaps it would be better to say that the curves do not coincide even approximately.

It is evident that the elements of sunlight, which are active in promoting the action of the chlorophyll cells in the formation of sugar, do not depend upon the direct rays of the sun. The diffused light coming through the clouds is apparently quite as effective as the direct light. The highest percentage of sunshine found in any of the stations plotted was at Lexington, Ky., reaching nearly 75 per cent of the possible hours of sunlight. The lowest percentage of direct sunshine was found at Agricultural College, Mich., being 59.2 per cent. Interesting data are also given in connection with the total sunshine by the boxed lines showing approximately the distribution of the sunshine in the various months, i. e., the number of clear days.[1] In order to show the complete relation, however, this line must be taken in connection with the number of cloudy and partly cloudy days. A striking illustration of this is shown by the data at Lexington, Ky., for June. During this month there were four clear days, and therefore the boxed line for June in the Lexington column is very short. The number of cloudy days was only seven, and there were nineteen days partly cloudy. In the study of the chart, therefore, it must be remembered in all cases that the boxed lines represent only the number of perfectly clear days. In Chart No. 1, therefore, it is seen that Raleigh, N. C., and Washington, D. C., have the largest number of clear days, while Madison, Wis., Ithaca, N. Y., Lafayette, Ind., and Lexington, Ky., are types of stations where the number of clear days was relatively small. No record was made for the station of Geneva, but the data may be assumed to be practically the same as for Ithaca. The value of the lines showing

[1] A clear day is one having on the average not more than three-tenths of the sky covered by clouds; a partly cloudy day is one having on the average from four to seven-tenths (inclusive) of the sky covered by clouds; and a cloudy day is one on which the sky is overcast or at least eight-tenths covered by clouds.—U. S. Weather Bureau.

the distribution of sunshine is therefore less than if all the elements entering into the sunshine could be combined into a single curve.

Chart No. 2 shows the curve for the sugar in the beet, the purity of the juice, the temperature, and the average length of the day. In this chart we have a remarkable illustration of the influence of high temperature upon sugar content. The two curves make almost an X-shaped figure. Low sugar and high temperature evidently go together. The highest temperature record for the summer was at Raleigh, N. C., and the lowest at Agricultural College, Mich. The temperature curve could also be very profitably compared with the latitude curve on Chart No. 1. It would form, also, an X-like figure with that curve. The purity of the juice shows a general tendency to follow the percentage of sugar, though there are many variations from this rule. In general, however, it is shown that the higher the percentage of sugar the higher the purity.

The curve showing the average length of day from sunrise to sunset has a direct relation also to the content of sugar in the beet. The shorter the day the lower the content of sugar and the longer the day the higher the content of sugar. This variation is doubtless partly due to the longer action of the sun's rays either directly or diffused through the clouds upon the sugar producing cells of the beet.

In Chart No. 3 are platted the curves showing the percentage of sugar in the beet, the total rainfall, the distribution of rainfall by months, and the altitude of the station above the sea level. The general influence of altitude, as is well known, is to lower the temperature for a given latitude. In other words, the altitude to a certain extent becomes a function of the latitude curve, and it would probably be advisable in some way to combine the two into a single curve. The highest altitude of the experimental stations collaborating (exclusive of Logan, Utah, which is not included in the charts) is at Lexington, Ky., namely, 979 feet; the lowest (sea level) at Washington. Other notably high stations are at Ames, Iowa, and Madison, Wis., and other notably low stations are at Raleigh, N. C., and Geneva, N. Y.

A more important relation to sugar content is shown by the rainfall, especially in its distribution. The total amount of rainfall, it is evident, has less influence on the sugar content than its even distribution during the growing months, providing the rain is sufficient for the growing crop. The greatest rainfall shown by any of the stations was at Ames, Iowa, and the lowest at Ithaca, N. Y. The rain at Ames was evidently far in excess of the requirements of the growing crop. The Washington rainfall was quite sufficient in quantity, but it was extremely uneven in distribution. For instance, during the month of June about 11 inches of water fell in Washington, while in July and August, when water was most needed, the amount was only about 1 and 2 inches, respectively. A very even distribution of rainfall is shown in the station at Geneva,

N. Y., while the quantity was relatively small. The distribution of the rainfall, also, at Ithaca was somewhat even, but there was a slight excess in October at a time when it would be injurious to the beet in the way of inducing a second growth. On the other hand, the September rainfall at Ithaca was small, thus favoring the ripening of the beet. The ideal conditions for the growth of the beet are an even distribution of the rainfall of from 3 to 4 inches during the months of May, June, July, and August, and a reduction of the rainfall for September and October.

The above conclusions, derived from these studies of a year, are quite in harmony with the theories which already prevail in regard to the effect of seasonal influences upon the sugar content of the beet. There are many problems, however, presented by the data which offer an inviting field of study. Chief among these is the suggestion, which has already been made in a previous part of this bulletin, that the high temperature line which seems to be so disastrous in its effects upon the sugar content of the beet may not produce all these ill effects directly as the result of the high temperature, but indirectly in the effect produced upon the moisture in the soil, the arrest of growth by dry weather, the inducement of a second growth on the accession of rains following a drought, and in other indirect ways. The study of this problem would best be carried on in an irrigated arid region where the temperature is high during the growing months and where the distribution of water on an experimental plat could be absolutely controlled. Other new problems of interest are also presented in studying the effects of direct and indirect sunshine and the distribution of the hours of direct sunshine compared with indirect and with partly cloudy weather.

In the study of these problems so far we are indebted to the cordial cooperation of the Weather Bureau and experiment stations, and in the further elaboration of them we rely on the promise of the continuance of this aid. It is certain that environment, of which meteorological conditions form the chief component, have a most marked influence on the chemical composition of crops, and without the assistance of the Weather Bureau it would be difficult to properly study the extent of the changes produced.

The analytical work in connection with these investigations was conducted by Dr. G. L. Spencer, in charge of the sugar laboratory of this Bureau, to whom I am indebted for many suggestions in the preparation of this bulletin.

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U. S. DEPARTMENT OF AGRICULTURE.

BUREAU OF CHEMISTRY—BULLETIN NO. 74.

H. W. WILEY, Chief.

THE INFLUENCE OF SOIL AND CLIMATE

UPON THE

COMPOSITION OF THE SUGAR BEET, 1901.

BY

HARVEY W. WILEY,

CHIEF OF BUREAU.

IN COLLABORATION WITH THE WEATHER BUREAU AND THE AGRICULTURAL EXPERIMENT STATIONS OF INDIANA, IOWA, KENTUCKY, MICHIGAN, NEW YORK, UTAH, VIRGINIA, AND WISCONSIN.

WASHINGTON:

GOVERNMENT PRINTING OFFICE.

1903.

LETTER OF TRANSMITTAL.

U. S. DEPARTMENT OF AGRICULTURE,
BUREAU OF CHEMISTRY,
Washington, D. C., December 31, 1902.

SIR: I have the honor to transmit for your approval manuscript and graphic charts embodying the results of the cooperative work conducted by this Bureau in the study of the effect of environment upon the composition of the sugar beet during the year 1901. To the work as conducted in 1900, the results of which were published in Bulletin 64, Bureau of Chemistry, has been added the consideration of the influence of the soil. I recommend that this manuscript be published as Bulletin No. 74, Bureau of Chemistry.

I wish again to express my appreciation of the work done by the various stations taking part in the experiment, the continued cordial cooperation of the Weather Bureau, which is of vital importance, and the information received from the Coast and Geodetic Survey and the Naval Observatory in response to the request made for geodetic data. The analytical work done in this Bureau was performed, under the direction of Mr. G. L. Spencer, by the assistants in the sugar laboratory, namely, H. W. Houghton, A. W. Bache, and Arthur Given.

Respectfully,

H. W. WILEY,
Chief of Bureau.

Hon. JAMES WILSON,
Secretary.

CONTENTS.

ILLUSTRATIONS.

THE INFLUENCE OF SOIL AND CLIMATE UPON THE COMPOSITION OF THE SUGAR BEET, 1901.

ORGANIZATION OF COLLABORATIVE WORK.

In continuation of the cooperative experimental work with sugar beets carried on in 1900[a] by this Bureau in collaboration with certain experiment stations and the Weather Bureau, the following letters were addressed to the experiment stations of North Carolina, Iowa, Michigan, Utah, Indiana, Wisconsin, Kentucky, and to the two New York stations in the spring of 1901:

MARCH 18, 1901.

DEAR SIR: For the collaborative work in the study of the influence of environment on the composition of the sugar beet for the present year, I have decided to use seed No. 5772, Dippe's Kleinwanzlebener Elite, and 20 pounds of this seed marked "special" have been sent to you for such collaborative work.

The area planted need not exceed an eighth of an acre, unless you desire a larger area or a number of plots. This matter is left entirely to your own judgment, and the residue of the seed you can dispose of as you like. I suggest, however, that the special plot be seeded very heavily, so as to be sure of a good stand, and that enough of the seed be reserved for replanting in case the first planting should not germinate.

I will send you in a few days a blank giving some special points in regard to the study of the environment which I should be glad to have you observe during the season.

H. W. WILEY, *Chemist.*

MARCH 18, 1901.

DEAR SIR: In connection with the collaborative study of the influence of environment on the composition of the sugar beet, I desire to make a careful chemical and physical analysis of the soils of the plots used for the growing of the beets.

I therefore ask that you take a representative sample of the soil and subsoil of the plot on which you grow the No. 5772 "special" seed during the present year. After getting such a sample, reduce it in size by quartering or otherwise, so as to secure a representative subsample weighing about 4 pounds, and send under the inclosed frank by mail to my address.

H. W. WILEY, *Chemist.*

On March 20, 1901, the seed was mailed to the stations named by the Section of Seed and Plant Introduction, and on March 23 the following letter was addressed to the cooperating stations:

MARCH 23, 1901.

DEAR SIR: In order that I may be put into direct communication with the official of your station who will be in personal charge of the collaborative work on the study

[a] Results published in Bulletin No. 64, Bureau of Chemistry, U. S. Department of Agriculture, 1901.

of the influence of environment on the sugar beet, I write to ask that in case you delegate this work to one of your assistants you inform me of that fact. In case you take personal charge of it please let me know also, in order that I may have an official record of the person immediately in charge.

H. W. WILEY, *Chemist.*

These letters were also later addressed to the Virginia station at Blacksburg. The responses showed that the following stations and officials would take part in the work:

Washington, D. C., G. L. Spencer; Lafayette, Ind., H. A. Huston; Agricultural College, Michigan, J. D. Towar; Ames, Iowa, James Atkinson; Lexington, Ky., M. A. Scovell; Geneva, N. Y., G. W. Churchill; Ithaca, N. Y., L. A. Clinton; Logan, Utah, John A. Widtsoe; Blacksburg, Va., W. B. Alwood; Madison, Wis., R. H. Shaw.

The work at the North Carolina station was temporarily abandoned, owing to a change in the personnel of the station.

On April 8, 1901, a final letter of instructions was sent out to the stations above-named, which read as follows:

APRIL 8, 1901.

DEAR SIR: I feel that it is scarcely necessary to make any suggestions in regard to the methods of planting and cultivating the beets which you undertake to grow in collaboration with this division. The seed, No. 5772 "special," you have probably already received. If not, please let me know at once.

Some time before sowing, preferably the previous autumn, the soil should be plowed to the usual depth of 8 or 9 inches, and subsoiled 6 inches deeper, making a seed bed at least 15 inches in depth. If the character of the soil warrants it, a deeper plowing, even to 10 or 11 inches, and a subsoiling of 6 inches additional will be advisable.

The surface of the soil should be reduced to a fine tilth, and be well harrowed and stirred immediately before planting, so as to stop all growth of weeds which may have been started.

The rows should be 18 inches apart, and the seed be planted at the rate of about 25 pounds per acre, so as to be sure of a good stand. If the soil be moist, the seed should be covered to a depth of from one-half to 1 inch. If the weather be dry, slightly deeper planting may be advisable.

So soon as the plants are growing vigorously they should be separated into clumps by a hoe 6 inches in width, leaving the length of 3 inches of beets in each hill. When the beets have a vigorous growth and begin to form the fourth leaf, they should be thinned to about one plant in each 9 inches. Where vacancies occur in a row, transplant carefully so as to have the number of plants indicated above.

Ordinary surface cultivation is all that is required, taking care not to cover up the beets at the first cultivation.

In sending the samples of soil, in accordance with previous instructions, do not forget to send a history of the plot, so far as known. Complete cultural and meteorological data in collaboration with the Weather Bureau should be kept and forwarded with the samples. Franks for forwarding samples and full instructions for harvesting and sampling will be sent later. It is earnestly requested that frequent analyses be made also at the station, so that the results of those analyses can be compared with those which are made of beets sent here.

Any questions in regard to further details will be cheerfully answered.

Respectfully,

H. W. WILEY, *Chemist.*

The following letter in regard to harvesting was forwarded to the cooperating stations under date of September 15:

DEAR SIR: Relative to the sugar beets grown by you from seed marked "No. 5772 special:"

When the beets appear to be approaching maturity and before any second growth can take place, please harvest a sufficient quantity to enable you to make a fair estimate of the yield per acre. Select 30 average beets from those harvested, have the tops removed, leaving about an inch of stems, and wash and wipe the roots.

Pack the carefully dried beets in a box, inclose full data relative to the sample on the slip "A," and forward the package to me by express, charges collect.

I will forward you the necessary slips "A" and envelopes. Please repeat this sampling and the estimate of yield at intervals of a week until end of season, timing the shipments, if practicable, so that packages will not reach here Saturday or Sunday.

Keep accurate data of all field work, which please transmit at end of season.

Respectfully,

H. W. WILEY, *Chief.*

Slip "A," referred to in the above letter, calls for the following data: Variety; when planted; when thinned; when harvested; date of shipment of sample; character of the soil; width between rows, inches; character of the growing season, favorable or unfavorable; estimated yield per acre, tons; remarks.

EXPERIMENTS CONDUCTED AT WASHINGTON, D. C.

Fourteen rows of the Dippe Kleinwanzlebener Elite beet seed (S. P. I. No. 5772) were sown on the experiment farm at the Potomac Flats on May 18. They showed above the ground on May 25, and were cultivated once a week and oftener when there were frequent rains. Between June 11 and 14 the beets were thinned, one-half being allowed to remain 8 inches apart and the other 12 inches apart. The distance between the rows was 18 inches. Hand hoes and rakes were used for the first cultivation, after which wheel hoes were employed. In the following tabulated data the thick stand and the thin stand of beets have been separately considered for purposes of comparison.

Agricultural and analytical data on beets grown on the experiment farm, Potomac Flats.

THICK STAND (PLANTS 8 INCHES APART).

When received.	Removed in topping.	Average weight after topping.	Estimated yield per acre.	Sugar in juice.	Sugar in beet.	Purity coefficient.
1901.	*Per cent.*	*Ounces.*	*Tons.*	*Per cent.*	*Per cent.*	
September 26	33.4	6.6	8.3	7.4	.....	66.7
October 3	31.6	6.2	7.6	7.3	7.1	65.8
October 10	34.1	6.7	7.9	7.8	7.5	68.4
October 17	33.5	5.9	8.1	8.0	7.8	67.2
October 24	33.0	6.7	8.1	8.6	8.4	65.6
October 31	22.5	8.6	11.8	9.4	9.1	69.1
November 7	34.0	6.7	5.1	8.8	8.5	67.7
November 21	34.2	5.1	7.0	10.6	10.3	68.8
Averages	32.0	6.6	8.0	8.5	8.4	67.4

Agricultural and analytical data on beets grown on the experiment farm, Potomac Flats—Continued.

THIN STAND (PLANTS 12 INCHES APART).

When received.	Removed in topping.	Average weight after topping.	Estimated yield per acre.	Sugar in juice.	Sugar in beet.	Purity coefficient.
1901.	*Per cent.*	*Ounces.*	*Tons.*	*Per cent.*	*Per cent.*	
September 26	35.1	10.4	7.0	7.3	.....	65.2
October 3	39.0	9.9	10.1	7.4	7.2	65.5
October 10	30.6	8.5	9.9	7.8	7.5	66.6
October 17	34.3	8.5	7.8	8.2	8.0	66.6
October 24	39.9	7.2	7.5	9.0	8.7	66.6
October 31	24.6	10.7	8.6	10.2	9.9	70.8
November 7	39.2	8.0	6.6	9.6	9.3	67.6
November 21	35.6	10.1	8.2	10.0	9.7	68,5
Averages	34.8	9.2	8.2	8.7	8.6	67.2
General averages	33.4	7.9	8.1	8.6	8.5	67.3

A comparison of the two plats represented by the tables under "thick stand" and "thin stand" shows that the crowding of the beets produced a marked effect upon the average weight, which in the "thick" plat was 6.6 ounces and in the "thin" plat 9.2 ounces, after topping. The term "topping" means the removal of the top of the beet at the neck, as in preparation for the factory. The beets were undersized on both plats, which is a matter of remark, inasmuch as the soil is composed of the deposit from the Potomac River bottom and is considered quite fertile, producing abundantly other crops grown in the same field. The yield per acre on the two plats was almost identical, the thin stand having a slight advantage. In regard to the yield of sugar the two plats are very close together, but contrary to expectation the small beets in the "thick stand" plat had slightly less sugar than the beets of larger growth. The purity in both plats was extremely low, but was slightly higher in the "thick stand" plat.

The meteorological conditions under which these beets were grown are shown in the following table:

Meteorological data for Washington, D. C., 1901.

Month.	Mean temperature.	Total precipitation.	Sunshine.			Clear days.	Cloudy days.
			Actual.	Possible.	Per cent.		
	° *F.*	*Inches.*	*Hours.*	*Hours.*			
May	62.5	2.81	197.1	443.8	44	10	16
June	72.4	4.66	329.8	445.9	74	18	6
July	79.8	5.17	273.6	453.0	60	12	7
Averages and totals	71.6	12.64	.....	.....	59.3	40	29
August	76.0	4.12	267.3	423.2	63	11	9
September	67.4	1.61	245.4	373.4	66	11	5
October	55.6	0.97	268.0	346.0	77	19	6
Averages and totals	66.3	6.70	.....	.....	68.7	41	20
General averages and totals	69.0	19.34	.....	.....	64.0	81	49

The meteorological conditions were quite favorable to the growth of beets, especially in respect of the distribution of the rainfall. In the three months most important to growth, namely, June, July, and August, the rainfall was abundant, while in September, the month most favorable to ripening, and in October, the month of harvest, the rainfall was deficient. In respect of distribution of rainfall, therefore, the season was ideal for the growth of a sugar beet. The temperature of the three principal growing months, as was to be expected, was very much in excess of the maximum which is found to be best suited to the production of beets of high sugar content. The excess above the maximum of 70° F. for June was 2.4°, for July 9.8°, and for August 6°. The distribution of the clear and cloudy days was also favorable to the growth of the beets. Aside from the temperature, therefore, it may be said that the meteorological conditions under which these beets grew were extremely favorable. It would appear from the consideration of this single plat that the temperature is the most important factor in the production of a high-grade beet.

EXPERIMENTS CONDUCTED BY THE INDIANA STATION

Prof. H. A. Huston makes the following report as to the cultivation of the beets grown from the Dippe Kleinwanzlebener Elite seed at Lafayette:

The special sugar-beet seed, No. 5772, furnished us by the Department in 1901, was planted on April 30, 1901. The land was plowed and subsoiled and was in fair condition at the time of planting. As two quite hot days preceded the planting, the soil temperature was sufficiently high. The seeds were planted in plats of six rows each, there being four plats. The rows were about 20 rods long, but the sampling was done upon the north end of the field because the conditions were more uniform there. The spaces between the four plats were filled out by three plats of 6 rows each from the other seed furnished by the Department. Samples of the soil and subsoil were drawn on May 1, 1901, and forwarded to the Department. The beets came up on May 9. The stand was not very good nor uniform, although double the usual amount of seed was used. As the season progressed the stand became still more uneven and was little improved by transplanting, although at two periods when conditions seemed to be favorable beets were transplanted to fill the vacancies. The beets were thinned to 8 inches in the row, and the rows were 22 inches apart. The cultivation was kept up into July. The season was decidedly unfavorable on account of the lack of moisture, and this fact combined with the rather uneven stand gave a low yield, although the beets were of very good quality. On November 1, the average yield from the four plats of No. 5772 was 5.4 tons of washed capped beets per acre. The weighings upon the other plats showed that the yields were not materially different from this. The last samples were drawn on November 1. On November 4, the ground froze and remained frozen for several days, and no further work was done upon the field, since the beets were badly frozen to a depth of 3 inches. Previous to the heavy freeze the bulk of the field had been harvested, a small portion only being left to study the question of ripening.

Agricultural and analytical data on beets grown at the Indiana experiment station, Lafayette.

When received.	Removed in topping.	Average weight after topping.	Estimated yield per acre.	Sugar in juice.	Sugar in beet.	Purity coefficient.
	Per cent.	*Ounces.*	*Tons.*	*Per cent.*	*Per cent.*	
September 20	.....	6.3	.....	12.1	.....	85.2
October 5	.....	6.2	.....	15.5	.....	93.3
October 26	.....	7.7	.....	15.5	.....	91.7
October 28[a]	14	8.2	.....	15.1	14.6	82.5
November 1	.....	6.4	5.4	16.7	.....	90.7
Average	14	7	5.4	15	14.6	88.7

[a] These analyses were made at Lafayette, with the exception of the one dated October 28, which was made at Washington from a sample corresponding to that analyzed on October 26 at the Indiana station.

The data for Lafayette show the growth of a beet very much undersized, the average size of the topped beet as prepared for the factory being only 7 ounces. The average yield per acre was also only about one-half the normal average—namely, 5.4 tons—though this figure is open to suspicion, only one estimate having been made. The percentage of sugar in the beets was quite high, and the purities were phenomenally high, as has been the case in previous reports. In the sample analyzed in the Bureau of Chemistry the purity was found to be 82.5, which leads us to believe that some modification of the ordinary method of ascertaining purity is used at the Lafayette station, which is the cause of the phenomenally high figures. In the platting of the curves in the charts which follow, the data used are those obtained in the Bureau of Chemistry on October 28.

The meteorological data for Lafayette and Indianapolis as given in the following tables illustrate clearly the conditions of drought and excessive sunshine that prevailed, although the actual average temperature was 1.2° lower than in 1900.

Meteorological data for Lafayette, Ind., 1901.

Month.	Mean temperature.	Precipitation.	Clear days.	Cloudy days.
	° *F.*	*Inches.*		
May	59.5	2.89	2	14
June	72.9	4.46	8	11
July	81.1	.44	18	2
Average and total	71.2	7.79	28	27
August	75.5	2.50	10	12
September	66.8	1.34	15	6
October	56.1	4.78	21	7
Average and total	66.1	8.62	46	25
General average and total	68.6	16.41	74	52

The sunshine record for Indianapolis, the nearest station at which sunshine records were kept, is shown in the following table:

Meteorological data for Indianapolis,[a] Ind., 1901.

Month.	Mean temperature.	Precipitation.	Sunshine.			Clear days.	Cloudy days.
			Actual.	Possible.	Per cent.		
	° *F.*	*Inches.*	*Hours.*	*Hours.*			
May	60.2	2.45	228.5	446.7	51	8	12
June	73.6	3.52	297.6	449.0	66	7	5
July	82.0	.83	396.3	455.2	87	19	0
Average and total	71.9	6.80	.....	.....	68	34	17
August	75.2	3.57	286.7	425.2	67	7	6
September	67.4	.66	284.1	373.6	76	14	2
October	56.7	3.52	247.8	344.9	72	17	7
Average and total	66.4	7.75	.....	.....	71.7	38	15
General average and total	69.2	14.55	.....	.....	69.85	72	32

[a] Fifty-nine miles southeast of Lafayette, Ind.

As will be seen from the preceding page the rainfall at Lafayette was very small, being only 16.41 inches as compared with 30.52 inches in 1900, and, moreover, the distribution was very unfavorable. In July, which is the principal growing month, there was scarcely any rain at all, while the supply for August was very moderate, and that for September still less. On the other hand, during October, the harvesting season, the rainfall was excessive. Thus it is seen that the distribution of the rainfall was not at all favorable to the production of the crop.

The temperatures for the growing season were above the maximum for the production of beets of the highest quality, being 2.9 degrees above 70° F. for June, 11.1 degrees above 70° F. for July, and 5.5 degrees above 70° F. for August. There is a remarkable contrast between the character of the beets grown at Lafayette and those at Washington, D. C., where it appears that the high temperature interfered very seriously with the production of sugar in the beet. In the case of Lafayette this effect does not appear, and the conclusion to be drawn from these data would be contrary to that reached at the Washington station. In this case it seems to be the latitude which is the predominating factor. The distribution of clear and cloudy days was very irregular, October having the largest number of clear days, although it was a month of heavy precipitation, July coming next and September third. The total number of clear days was 10 greater than in 1900, and the percentage of sunshine, as observed for Indianapolis, was 5.1 per cent higher.

The meteorological data for Indianapolis, about 59 miles southeast of Lafayette, are interesting for comparison. It is seen that the temperature and precipitation average about the same for the two points, but the distribution of the rainfall is slightly different, being heavier during August at Indianapolis and lighter during September. The

total precipitation for the six months, however, was slightly greater at Lafayette, while the average temperature, as might be expected, was a little higher at Indianapolis.

Under date of October 28, Professor Huston, in commenting on the prevailing meteorological conditions during the beet season of 1901, says:

As you are doubtless aware, the summer season has been quite unusual in this section, the drought being so severe that the corn crop will be reduced fully one-half; on our own farm we have practically no corn.

Your circular of September 15, was received, but since the beets had not appeared to approach maturity, but were simply standing still from lack of water, I did not deem it wise to send samples at that time. On September 20, I sampled a field, and the results you will find on inclosed card; on October 5, I sampled again, and you will see that between these dates the beets had made a very substantial gain in both sugar content and purity. No rain fell between these dates. On October 11, a general rain set in, and in four days we had 4.35 inches of rain. The beets started to grow, but you will see from the results of the analyses on October 26, that the sugar content was not reduced. This is an unusual result, and from now on we shall sample the field every few days to see what takes place. The drought reduced the stand of beets fully one-half, but those remaining are of marketable size and very good quality.

I regret very much that the beets are not so situated that we could have tried irrigation on them, for it would have been a banner year for the purpose.

EXPERIMENTS CONDUCTED BY THE IOWA STATION.

The beets were planted at the Iowa station on May 22, thinned on June 20, and harvested for the first time on October 7. Mr. James Atkinson, assistant in agriculture at Ames, writes as follows concerning the beet crop on September 23, 1901:

I may say that, while our beet crop has run the gauntlet of many foes this year, still it looks exceedingly well at the present time. You are, no doubt, aware that our crop suffered considerably from the hot winds and drought during the summer. I found that the beet crop stood it about as well as any other crop, although it was not by any means exempt from injury. The blister beetles also gave us considerable trouble, and we were compelled to fight four broods of them with Paris green and London purple. However, it appears at the present time that we have come out on top and that we shall have beets of good quality to harvest. * * * Sugar making has scarcely commenced yet, the beets being only slightly sweet to the taste. I think the first harvesting will be ready about October 1.

The results of the analyses made at Washington of the three samples of beets forwarded are found in the following table:

Agricultural and analytical data on beets grown at the Iowa Experiment Station, Ames.

When received.	Removed in topping.	Average weight after topping.	Estimated yield per acre.	Sugar in juice.	Sugar in beet.	Purity coefficient.
1901.	*Per cent.*	*Ounces.*	*Tons.*	*Per cent.*	*Per cent.*	
October 10	18.7	13.4	12.1	13.7	13.3	80.6
October 21	20.1	12.6	12.8	14.4	13.9	79.6
November 5	14	16.7	13.8	15.7	15.1	80.5
Average	17.6	14.2	12.9	14.6	14.1	80.2

The agricultural and analytical data for Iowa show beets of fine character, very favorable yield per acre, and satisfactory purity. The average weight of the beets, prepared for the factory, was 14.2 ounces and the estimated yield per acre 12.9 tons. The percentage of sugar in the beet was 14.1 and the purity 80.2. These data must be regarded as exceedingly favorable, especially in view of the climatic conditions under which the beets were grown.

The following detailed statement of the meteorological conditions shows the extent of the drought referred to by Mr. Atkinson, the rainfall for the six months being only 16.15 inches, as compared with 36.29 inches the preceding year. The temperature was practically the same, the record for 1900 showing an average of 68.2°.

Meteorological data for Ames, Iowa, 1901.

Month.	Temperature.	Precipitation.	Clear days.	Cloudy days.
1901.	°F.	*Inches.*		
May	61.4	3.69	17	5
June	74.4	2.36	21	1
July	83.3	2.26	27	1
Average and total	73.0	8.31	65	7
August	72.8	1.21	25	1
September	61.6	3.65	16	7
October	53.9	2.98	21	4
Average and total	62.8	7.84	62	12
General average and total	67.9	16.15	127	19

The sunshine record is taken from a table of meteorological data for Des Moines, Iowa, about 30 miles south of Ames, that being the nearest station at which sunshine records were kept:

Meteorological data for Des Moines, Iowa, 1901.

Month.	Temperature.	Precipitation.	Sunshine.			Clear days.	Cloudy days.
			Actual.	Possible.	Per cent.		
1901.	°F.	*Inches.*					
May	61.6	1.40	312.7	451.9	69	12	6
June	73.4	2.41	329.1	456.2	72	11	3
July	84	1.72	390.1	461.8	84	15	1
Average and total	73	5.53	.....	.....	75	38	10
August	75	0.67	318.9	429.4	74	13	3
September	64.8	2.60	199.9	374.5	53	9	9
October	56.2	2.14	230	342.5	67	13	9
Average and total	65.3	5.41	.....	.....	64.7	35	21
General average and total	69.2	10.94	.....	.....	69.85	73	31

These data show that the months of June, July, and August were considerably above the desired temperature, the month of July especially having been excessively hot both at Ames and at Des Moines. The heat coupled with a very insufficient rainfall, July and

August showing a very small precipitation, made the season unusually dry. The data for Des Moines show a much smaller precipitation and at the same time a much smaller number of clear days than the data for Ames. These data show that the beet crop, properly planted and cultivated, is independent of variations in precipitation to a surprising extent. The total precipitation during the growing season at Ames for 1901 was considerably less than one-half that of the previous year and yet no deleterious effect was produced thereby on the size of the beets. In this respect and in quality the beet crop was markedly superior to that of 1900. These data are valuable as showing that, in regions where deficient rainfall may occur during the summer time, the sugar beet may produce a satisfactory crop if the proper attention is paid to the preparation of the soil and the cultivation.

EXPERIMENTS CONDUCTED BY THE KENTUCKY STATION.

The special beet seed was planted at Lexington, Ky., on April 29, 1901, 18 inches between the rows, thinned on May 23 and June 10, and harvested on October 17. The soil was plowed 8 inches deep and subsoiled 5 inches.

The analysis made at Washington of a sample of these beets gave the following data:

Agricultural and analytical data on beets grown at the Kentucky Experiment Station, Lexington.

When received.	Removed in topping.	Average weight after topping.	Estimated yield per acre.	Sugar in juice.	Sugar in beet.	Purity coefficient.
1901.	*Per cent.*	*Ounces.*	*Tons.*	*Per cent.*	*Per cent.*	
October 21	25.2	10.4	8	9.3	9	71

The analytical and agricultural data obtained at Lexington during the season are as follows:

Agricultural and analytical data determined at the Kentucky station.

Date of sampling.	Number of beets.	Average weight topped.	Sugar in juice.	Purity coefficient.
1901.		*Ounces.*	*Per cent.*	
July 11	1	.....	8.1	63.7
July 27	4	8	9.4	70.3
August 1	4	9.7	12.1	75.4
August 19	4	10.9	9.7	77.2
August 23	3	10.7	9.9	77.2
October 16	10	12.5	10.1	75.7
Average	.....	10.4	9.9	73.3

The data for the Kentucky station show that the beets produced there were slightly under the normal size, and neither the content of sugar nor the purity was high enough to enable these beets to compete

in sugar making with beets grown in more northern localities. The analysis of the single sample of beets made at Washington gave almost the same data as the average of the analyses made at the Kentucky station from July 11, to October 16, inclusive. From the analyses made at the Kentucky station it appears that the beets reached their highest content of sugar early in August, but too much stress must not be laid upon a single analysis. From the middle of August to the middle of October there was not a very large variation in the content of sugar in the beets.

Mr. Scovell states that the early season was favorable, but that July and August were unfavorable. The climatic conditions, as shown in the following table, do not differ greatly from those of the preceding season, even as to total rainfall:

Meteorological data for Lexington, Ky., 1901.

Month.	Mean temperature.	Total precipitation.	Sunshine.			Clear days.	Cloudy days.
			Actual.	Possible.	Per cent.		
	Degrees.	*Inches.*	*Hours.*	*Hours.*			
May	62.8	2.67	273.4	441.7	62	14	7
June	73.9	3.70	322.3	443.1	73	13	2
July	80.3	2.61	385	450.1	86	23	0
Average and total	72.3	8.98	.....	.....	73.7	50	9
August	74	3.74	305.5	422.1	72	10	5
September	67	2.18	276	373	74	13	2
October	57.9	1.33	288.4	347.3	83	22	2
Average and total	66.3	7.25	.....	.....	76.3	45	9
General average and total	69.3	16.23	.....	.....	75	95	18

The meteorological data show that the temperature of June and July was lower than at Ames, Iowa, although Lexington is about 275 miles south of Ames. The distribution of the rainfall at Lexington was fairly favorable, although the supply was not sufficient. There is, however, a remarkable uniformity of precipitation during the months from May to September, inclusive. The precipitation for October was small, which is distinctly favorable for beet culture.

Mr. Scovell further calls attention to the existing drought by a statement of the accumulated deficiency of precipitation from January 1, 1901, which in May amounted to 8.12 inches; in June to 8.67 inches; in July to 10.24 inches; in August to 10.59 inches; in September to 11 inches, and in October to 11.78 inches.

A slight improvement took place in the quality of the beets, the average of sugar in the beet having been 7.8 per cent and the purity coefficient 69.6 in 1900, as compared with 9 and 71 for 1901. The beets are, however, still considerably below the commercial standard, both as to sugar content and purity.

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EXPERIMENTS CONDUCTED BY THE MICHIGAN STATION.

As will be seen by reference to the following table, two sets of experiments were conducted at the Michigan station, field No. 3 having been planted May 16, with rows 18 inches apart, and thinned June 15, while field No. 6 was not planted until June 8, and was thinned July 8 and 9, the rows being 21 inches apart. The soil of field No. 3 is described as a sandy loam and that of field No. 6 as a gravelly loam. The constituents of the soil will be discussed in detail under that heading. While leaf spot checked the growth somewhat, the season was in general very favorable, cool, and with a great deal of sunshine. The data for both fields are as follows:

Agricultural and analytical data on beets grown at the Michigan Experiment Station, Agricultural College.

FIELD NO. 3, EARLY PLANTING, MAY 16, 1901.

When received.	Removed in topping.	Average weight after topping.	Yield per acre.	Sugar in juice.	Sugar in beet.	Purity coefficient.
1901.	*Per cent.*	*Ounces.*	*Tons.*	*Per cent.*	*Per cent.*	
September 26	21.9	8.8	13.6	12.5	.....	79.1
October 10	16	8.8	14.5	14.4	13.8	79.6
October 15	10.2	10.9	14.5	15.4	14.9	81.5
October 18[a]	14.2	8.2	16.9	14.1	13.7	80.1
November 2[a]	19.1	9.4	16.1	15.3	14.8	80.1
November 8	25.5	10.1	14.5	16.5	16	82.9
November 14	22.4	13.7	15.4	15.2	14.7	80.4
Average	18.5	10	15.1	14.8	14.7	80.5

FIELD NO. 6, LATE PLANTING, JUNE 8-9, 1901.

September 26	15.1	5.4	5.3	12	11.7	79.5
October 10	12.5	6.4	5.4	14	13.4	89.9
October 15	11.8	4.1	5.4	14.8	14.3	82
October 18[a]	14.2	8.2	4.7	14.1	13.7	80.1
November 2[a]	19.1	9.4	5.1	15.3	14.8	80.1
November 8	24.2	6.4	4.6	17.4	16.6	83.7
November 14	23.7	7	6.6	16.8	16	82.4
Average	17.2	6.7	5.3	14.9	14.4	82.5
General average	17.9	8.3	10.2	14.9	14.6	81.5

[a] In the two packages arriving on these dates the beets harvested from the two fields could not be separated.

The analytical data furnished by the station showed an average weight of beets in the field of 13 ounces, 12.7 per cent of sugar in the beets, a coefficient of purity of 79.2, and a yield per acre of 11.6 tons.

In case of the early planting, while the average weight of the beets was slightly below the normal, the estimated yield per acre was far above the average, namely, 15.1 tons. The data for the late planting, June 8 and 9, field No. 6, show practically the same quality of beets as regards sugar content and an even higher purity, but, in so far as yield per acre is concerned, the crop was only about one-third that of the early planting.

The beets grown during 1901 were of a better quality than those of the preceding year, the percentage of sugar in the beet and the

coefficient of purity being each 1.5 higher. The beets were smaller, however, and the average yield per acre was lower. The data for the late planting are responsible for the decrease to a great extent, the figures for the early planting being but little lower than those for 1900.

The climatic conditions existing at Agricultural College and at Detroit during this season are shown in the following tables:

Meteorological data for Agricultural College, Mich., 1901.

Month.	Temperature.	Precipitation.	Clear days.	Cloudy days.
	° *F.*	*Inches.*		
May	55.2	2.42	10	14
June	68.0	3.57	13	2
July	74.2	5.08	22	3
Average and total	65.8	11.07	45	19
August	68.4	2.49	15	7
September	61.7	1.67	18	7
October	49.6	4.61	18	4
Average and total	59.9	8.77	51	18
General average and total	62.8	19.84	96	37

In the following table is given the sunshine record for Detroit, Mich., 76 miles southeast of Agricultural College, the nearest point at which sunshine records were kept.

Meteorological data for Detroit, Mich., 1901.

Month.	Temperature.	Precipitation.	Sunshine.			Clear days.	Cloudy days.
			Actual.	Possible.	Per cent.		
	° *F.*	*Inches.*	*Hours.*	*Hours.*			
May	56.6	2.76	222.2	451.9	49	5	10
June	68.8	2.08	286.5	456.2	63	9	8
July	76.8	5.50	333.4	461.8	72	18	3
Average and total	67.4	10.34	.....	.....	61.3	32	21
August	71.9	3.20	238.3	429.4	55	10	6
September	64.8	1.65	244.5	374.5	65	13	4
October	52.8	1.90	231	342.5	67	16	3
Average and total	63.2	6.75	.....	.....	62.3	39	13
General average and total	65.3	17.09	.....	.....	61.8	71	34

These data show an abundant rainfall during the three principal growing months, especially in July, when the amount appears to be excessive. September was a dry month, favorable to the ripening of the beet, while, on the other hand, October was a wet month and unfavorable to the harvesting. The figures for Detroit show practically the same conditions as those prevailing at Agricultural College. A comparison of the meteorological data with that for 1900 shows that there was a fall in the average temperature of 1.7 degrees and an increase in the precipitation of 2.3 inches, while the percentage of sunshine increased 2.6 per cent.

EXPERIMENTS CONDUCTED BY THE NEW YORK STATION AT GENEVA.

The experimental beet plots at the Geneva station were planted on June 10, with 20 inches between the rows, and were thinned from July 10 to 20. Special fertilizer experiments were conducted at this station, which will be further discussed under soil. The season was reported as being favorable, and the following analytical data, as determined at Washington, bear out this report, the beets from Geneva outranking any others grown as to sugar content and purity, standing second in size and yield.

Agricultural and analytical data on beets grown at the New York experiment station, Geneva.

When received.	Removed in topping.	Average weight after topping.	Estimated yield per acre.	Sugar in juice.	Sugar in beet.	Purity coefficient.
1901.	*Per cent.*	*Ounces.*	*Tons.*	*Per cent.*	*Per cent.*	
November 2	16.8	19.7	.....	16.5	16.0	82.1
Do	15.9	18.4	.....	17.9	17.3	83.1
November 11	17.8	21.4	.....	14.9	14.4	79.7
Do	17.8	19.7	.....	15.8	15.3	83.2
December 24	38.3	10.8	.....	15.45	.....	82.6
Do	15.5	13.1	.....	17.2	.....	86.9
Averages	20.4	17.2	[a] 13.8	16.3	15.8	83.9

[a] Averaged from N. Y. Exp. Sta. Bul. No. 205, 1901.

As the conditions existing at Geneva seem to approach the ideal for sugar-beet culture, it is regretted that only the temperature and rainfall data are obtainable for that place. The sunshine data is not available for any nearer point than Ithaca. It is shown, however, that the decreased temperature in 1901, as compared with the previous year—i. e., 1.6°—and the increased rainfall of 3.4 inches had practically no effect on the quality of the beets, while their size was slightly increased. The meteorological data available are as follows:

Meteorological data for Geneva, N. Y., 1901.

Month.	Temperature.	Precipitation.
1901.	° *F.*	*Inches.*
May	56.9	3.80
June	68.9	2.07
July	76.6	3.97
Average and total	67.5	9.84
August	71	5.52
September	64	2.46
October	51.4	1.35
Average and total	62.1	9.33
General average and total	64.8	19.17

These data show a most favorable distribution of the rainfall during the growing season. There was not too much precipitation during May and June, the period of preparation. There was abundant precipitation during July and August, the period of rapid growth; a diminished precipitation during September, the period of ripening, and a very slight rainfall during October, the time of harvesting. No more ideal distribution of the rainfall could be desired.

EXPERIMENTS CONDUCTED BY THE CORNELL STATION AT ITHACA, N. Y.

The season at Ithaca is reported as having been favorable, and a comparison of the analytical data with that of the previous year shows that the beets were of practically the same high sugar content, although the purity was 2 points lower. While these beets are of excellent character, it is to be noted that the purity is not as high as would be expected in beets of their sugar content, being very slightly below the desired standard. The analyses made at the station give higher figures for both sugar content and purity than those obtained in our own work.

Agricultural and analytical data on beets grown at the Cornell experiment station, Ithaca.

When received.	Removed in topping.	Average weight after topping.	Estimated yield per acre.	Sugar in juice.	Sugar in beet.	Purity coefficient.
1901.	*Per cent.*	*Ounces.*	*Tons.*	*Per cent.*	*Per cent.*	
October 17	17.9	12.2	10.1	14.5	14.1	80
October 24	17.3	11.2	13	14.5	14.1	81.9
October 31	15.8	13.7	13	14.5	14.1	77.5
November 7	21.6	13.3	13.5	16.3	15.8	81.1
November 21	26.7	11	13	14.6	14.2	79.3
November 25	15.8	17.3	13	15.8	15.3	79.4
Average	19.2	13.1	12.6	15	14.6	79.9

Agricultural and analytical data prepared at the Cornell Station.

When harvested.	Average weight of beets.	Sugar in juice.	Sugar in beet.	Purity coefficient.
1901.	*Ounces.*	*Per cent.*	*Per cent.*	
October 15	12.5	15.85	15.06	82.6
October 22	10.0	16.05	15.25	82.3
October 29	8.0	16.65	15.85	80.5
November 5	13.5	19.40	18.43	84.0
November 19	10.0	16.60	15.77	81.0
November 21	16.5	18.75	17.80	83.0
Average	11.75	17.22	16.35	82.2

The climatic conditions under which these beets were grown are shown in the following table:

Meteorological data for Ithaca, N. Y., 1902.

Month.	Mean temperature.	Total precipitation.	Sunshine.			Clear days.	Cloudy days.
			Actual.	Possible.	Per cent.		
	°F.	*Inches.*	*Hours.*	*Hours.*			
May	55.8	4.20	219.6	451.9	49	6	16
June	67.8	3.06	344.7	456.2	76	10	8
July	74.3	3.60	369.4	461.8	80	5	8
Average and total	66.0	10.86	.....	.....	68.3	21	32
August	69.5	3.85	277.6	429.4	65	8	9
September	61.8	1.66	261.8	374.5	70	13	7
October	51.2	1.07	190.6	342.5	56	7	6
Average and total	60.8	6.58	.....	.....	63.7	28	22
General average and total	63.4	17.44	.....	.....	66	49	54

The meteorological data show an even distribution of rainfall, indicating, however, a larger precipitation in May and a smaller one in August than at the Geneva station. The dry weather of September and October was extremely favorable to the ripening and harvesting of the beets.

EXPERIMENTS CONDUCTED BY THE UTAH STATION.

The plat selected for the cooperative sugar-beet work was plowed and subsoiled on April 24, and seeded with a drill on April 27, 1901. The beets were thinned on June 1, and as late as June 19, were not suffering for water, at which time they stood 6½ inches. The dates of irrigation were July 1, 16, and 31; August 15; and September 3 and 16. The beets were cultivated on May 23, June 13, and July 3, the harvest taking place on November 4, 1901. The growth was uneven, there being vacant places in the rows. To the above report Director Widtsoe adds the following data, which differ somewhat from those obtained at the Washington office:

	Tons.
Yield per acre	23.91
Per cent sucrose in juice	17.05
Purity coefficient	81.0

The analytical and agricultural data obtained on the samples forwarded to Washington are as follows:

Agricultural and analytical data on beets grown at the Utah Experiment Station, Logan.

When received.	Removed in topping.	Average weight after topping.	Estimated yield per acre.	Sugar in juice.	Sugar in beet.	Purity coefficient.
1901.	*Per cent.*	*Ounces.*	*Tons.*	*Per cent.*	*Per cent.*	
October 3	14.7	26.1	24.7	12.4	11.9	75.0
October 10	13.7	23.1	22.0	14.6	14.1	79.8
October 14	9.9	24.2	.....	14.3	13.9	79.4
October 22	10.2	23.2	.....	17.2	16.7	82.3
Average	12.1	24.2	23.4	14.6	14.2	79.1

The data for the Utah station are given for reference and comparison, but of course are not platted with the other stations in the graphic charts. It is the intention during another year to include a series of comparative tests at irrigation stations when the data obtained for Utah will serve as an introduction. The most marked characteristic of the Utah beets is their large size, being fully one-third above the ideal average for sugar beets of high quality. The yield per acre is also far above that obtained at the other stations where irrigation is not practiced. The sugar content of the beets is entirely satisfactory, although the purity, as might be expected from the character of the soil and the method of culture, is somewhat low.

The meteorological conditions prevailing at Logan and the vicinity during the period of growth were as follows:

Meteorological data for Logan, Utah, 1901.

Month.	Mean temperature.	Total precipitation.	Clear days.[a]	Cloudy days.[a]
	Degrees.	*Inches.*		
May	60.6	2.43	21	7
June	61.4	0.41	20	2
July	76.7	.07	28	2
Average and total	66.2	2.91	69	11
August	72.8	1.60	21	8
September	59.2	1.03	22	8
October	53.6	1.83	18	10
Average and total	61.9	4.46	61	26
General average and total	64.0	7.37	130	37

[a] Record made at Corinne, 19 miles southwest of Logan.

In the following table is given the sunshine record for Salt Lake City, Utah, the nearest point at which sunshine records were kept, 66 miles south of Logan.

Meteorological data for Salt Lake City, Utah, 1901.

Month.	Mean temperature.	Total precipitation.	Sunshine.			Clear days.	Cloudy days.
			Actual.	Possible.	Per cent.		
	°F.	*Inches.*	*Hours.*	*Hours.*			
May	63.0	4.27	352.6	449.1	79	20	2
June	65.0	0.49	351.4	451.9	78	23	3
July	80.2	.31	386.0	458.6	84	19	2
Average and total	69.4	5.07	.....	.....	80.3	62	7
August	76.0	1.22	282.0	427.4	66	18	6
September	63.0	.66	302.9	374.0	81	21	3
October	55.6	.98	239.4	343.9	70	22	5
Average and total	64.9	2.86	.....	.....	72.3	61	14
General average and total	67.2	7.93	.....	.....	76.3	123	21

The meteorological conditions at Logan are interesting in showing the distribution of the precipitation and the variations in temperature. During July it is seen that only a trace of rain fell, while in August and October the precipitation compares favorably with that of some of the nonirrigated stations. The temperature at Logan during the growing season is decidedly lower than at the nonirrigated stations. July shows a high temperature, but June especially is low, and the August temperature is not much above 70°.

The data for Salt Lake City show practically the same distribution of precipitation as at Logan during the months of June, July, and August. The temperature, however, at Salt Lake was decidedly higher, especially during July, and the precipitation during the month of May was nearly twice as great as at Logan.

EXPERIMENTS CONDUCTED BY THE VIRGINIA STATION.

For the first time the experimental beet work was carried on at Blacksburg, in 1901, thus supplying a Southern station to take the place of North Carolina, where the work was temporarily discontinued.

The beets were planted on June 1, with 18 inches between the rows, thinned on July 5, and the first sample forwarded was harvested on October 12. The determinations of the percentage of sugar in the juice, as made at the experiment station, were as follows:

	Per cent.
September 20, 1901	6.65
September 30, 1901	8.95
October 12, 1901	12.62
October 22, 1901	12.69
October 31, 1901	12.77
Average	10.74

The analytical data obtained at Washington on the samples forwarded from Blacksburg and the climatic conditions prevailing during the period of growth are shown in the following tables:

Agricultural and analytical data on beets grown at the Virginia experiment station, Blacksburg.

When received.	Removed in topping.	Average weight after topping.	Estimated yield per acre.	Sugar in juice.	Sugar in beet.	Purity coefficient.
1901.	*Per cent.*	*Ounces.*	*Tons.*	*Per cent.*	*Per cent.*	
October 15	8.7	5.6	10+	11.6	11.2	75.5
October 24	20.6	4	.....	13.5	12.9	76.7
November 2	16	4	.....	15.8	15.3	80.2
Average	15.1	4.5	10	13.6	13.1	77.6

Meteorological data for Blacksburg, Va., 1901.

Month.	Mean temperature.	Total precipitation.	Sunshine.[a]	Clear days.	Cloudy days.
	° *F.*	*Inches.*	*Per cent.*		
May	58.7	6.71	.....	12	10
June	67.8	6.78	46.8	10	12
July	74	4.51	54.6	14	7
Average and total	66.8	18	50.7	36	29
August	68.6	10.53	40.8	7	12
September	61.6	2.59	61.3	15	9
October	52	.96	[b]68	21	3
Average and total	60.7	14.08	56.7	43	24
General average and total	63.8	32.08	53.7	79	53

[a] These data were averaged from weekly means furnished by Mr. Alwood.
[b] To October 19 only.

In commenting on the season at Blacksburg, Mr. Alwood, under date of October 12, says:

The weather conditions have been decidedly bad here this year, so that the crop is not extra heavy, but it can be considered a fair average. I think that at this time the beets are practically mature, but I fear that the wet season and consequent lack of sunshine will cause them to analyze very low in sugar. To the present time no second growth has begun; in fact, only a few of the bottom leaves have died. It is hardly probable that conditions as to sunlight will be such as to increase the sugar content very materially from this on.

It will be noticed that the general characteristics of the season at Blacksburg are in striking contrast to those at the other stations, unusual rains having prevailed at the former and drought at the latter. In forwarding the samples, Mr. Alwood said: "A more unfavorable year could not occur, but in this garden soil the result is fair."

A study of the agricultural and analytical data for Blacksburg shows a beet of phenomenally small size but of a fair average yield per acre. The sugar content of the samples was fair, but the purity was unsatisfactory. The high sugar content of this low latitude must be ascribed principally to the altitude of the station, which is about 2,100 feet. One of the principal objects in extending the collaborative work to Blacksburg was to determine the effect of altitude and its accompanying meteorological influences upon the sugar content of the beet. This object has been attained in a most striking manner in the preceding data.

The rainfall during the preparatory planting period was excessive. For the month of June it was abundant and for August far in excess of the quantity required for favorable growth. The precipitation for September and October, however, was favorable to the ripening and harvesting of the crop.

EXPERIMENTS CONDUCTED BY THE WISCONSIN STATION.

While the beets grown at the Wisconsin station were of very fair quality, they were far inferior to those of the previous season, showing a decrease of sugar in the beet of 2.5 per cent and a decrease in purity of 8.8. The beets grown in 1900 ranked next to the highest among the cooperating stations, and undoubtedly the falling off in quality in 1901 was due not solely to the drought (the total precipitation for the growing season being 7.7 inches less than in the previous year), but also in part to the unfortunate distribution of such rain as fell. The drought was most extreme in the first months of growth and the rainfall greatest in September and October, thus probably inducing a second growth and lowering the quality of the beets. The average temperature and the number of clear and cloudy days remained practically the same as in 1900, the rainfall being thus the only important variant.

The tables given below show the analytical data obtained at Washington on these samples and also the meteorological conditions under which the beets were grown:

Agricultural and analytical data on beets grown at the Wisconsin Experiment Station, Madison.

When received.	Removed in topping.	Average weight after topping.	Estimated yield per acre.	Sugar in juice.	Sugar in beets.	Purity coefficient.
1901.	*Per cent.*	*Ounces.*	*Tons.*	*Per cent.*	*Per cent.*	
October 1	10	8.2	11.375	13.5	12.9	80.3
October 9	15.1	8.3	9.3	14.1	13.5	82
October 16	9.4	11.4	12.8	11.1	10.8	71.2
October 24	14.9	15.8	10.5	13.8	13.4	76.2
Average	12.4	10.9	11	13.1	12.7	77.4

Meteorological data for Madison, Wis., 1901.

Month.	Mean temperature.	Total precipitation.	Clear days.	Cloudy days.
	° *F.*	*Inches.*		
May	57.8	2.41	4	15
June	70.4	2.40	5	12
July	79.6	1.54	12	9
Average and total	69.3	6.35	21	36
August	71.6	1.33	10	11
September	61.4	4.16	7	10
October	52.4	2.49	10	9
Average and total	61.8	7.98	27	30
General average and total	65.6	14.33	48	66

The following comment on the climatic conditions as shown in the above table is made by Mr. Shaw:

The season of 1901 was, as a whole, very unfavorable to most crops in Wisconsin. The extremely hot and dry weather during July and August did great damage to

crops all over the State, the southern part of the State suffering most from the drought. The average temperature of July was 4.8° F. above normal, and in the region along the western border of the State the average for this month rose 10° F. above the normal temperature. The rainfall during the season was very uneven, the average for the northern and central counties being nearly 23 inches for the seven months, March to September, and only about 14 inches for the southern counties. The total rainfall for the seven months was, on the average for the whole State, 20.41 inches, which is two-thirds of an inch below normal.

The following detailed report of the cultural data and other interesting items as to the season's work was forwarded by Messrs. Woll and Shaw, in charge of the cooperative work at the Wisconsin station:

The land was plowed early in the spring of 1901 and a few weeks later prepared in the usual manner for the planting of the beet seed by disking and pulverizing. The planting was done by means of a hand seeder on May 17, in rows running north and south, 18 inches apart. The experience of last year was duplicated this spring; a hard crust was formed on the land through heavy rains a few days before the young plants began showing themselves above ground; as most of the young plants probably would have been unable to break the crust formed, it was decided to reharrow and replant the entire plat, and this was accordingly done on June 7.

The plants began appearing above the ground about June 14. A terrific thunderstorm appearing on June 16 did great damage to the beets, as to all crops in this vicinity, and the soil of the eastern part of the field was washed badly, in places to a depth of 2 or 3 inches; in other places the young beet plants were covered to a similar depth. The field was thoroughly hoed, and although the crop at first seemed entirely ruined, the beet plants gradually recovered. In the eastern part they seemed struggling for existence against heavy odds for a week or more.

The plants were thinned from June 27 to July 1, a strong plant being left every 9 inches in the row. Owing to the severe drought, no transplanting was attempted. For over a month after this date no rain fell and the beets grew but little, the best stand being in the southwest corner and the poorest in the southeast corner of the field. The drought in this vicinity completely ruined some crops, and the prospects were at this time that there would not be a yield of 50 per cent of the usual average of any crop.

The sampling of the beets for analysis took place for the first time September 25, and from that time up to harvest the variety No. 5772 was sampled every week. The results of the analysis are given in the following table:

Agricultural and analytical data determined at Madison, Wis., on beets grown at that station.

Date of sampling.	Weight of trimmed beets.	Sugar in juice.	Sugar in beets.	Purity coefficient.
1901.	*Ounces.*	*Per cent.*	*Per cent.*	
September 25	9.6	12.6	12.0	77.2
October 4	8.0	13.7	13.0	78.4
October 11	10.7	10.8	10.2	71.6
Average	9.4	12.4	11.7	75.7

The sampling of No. 5772 was done by digging all beets in 60 feet of a row of average luxuriance and selecting three beets from the lot. Samples were forwarded to the Bureau of Chemistry, United States Department of Agriculture. The low results of analyses were due to the immature condition of the beets. A rainy period set in on October 7, which lasted for five days; over 2 inches of rain fell during this time.

The weather was raw and cold during the following days, and the harvesting was postponed as long as practicable, so as to give the beets a chance to mature. Other farm work and the uncertainty of the advanced season rendered it necessary, however, to begin the harvest on October 18. At that time the beets looked as if they were still growing; but few dead leaves were observed, and the general appearance of the beets was green and thrifty. The beets on the western half of the plat looked much better than those on the eastern half.

A bushel basket of beets was taken from each load hauled off the field (1 to 2 bushels of each variety). The samples thus secured were washed to determine shrinkage from adhering dirt. This amounted to 8.8 per cent for some of the different varieties, and on the average to 5 per cent. The results obtained at harvest were as follows:

Estimated yield per acre	tons	9.9
Sugar in the beets	per cent	10.9

The low results obtained during the past season with the university farm beets were somewhat of a surprise to us, although we did not expect much this year from the adverse conditions under which the beets grew throughout the season, the most important of which was the late date of planting. The peculiar climatic conditions, together with the short growing period which the beets had, fully explain the results, and also show that soils which in ordinary seasons will produce rich beets, higher in sugar than the common factory standard by at least several per cent, as has been generally the case on our university farm soil, may with the same kind of careful culture under exceptionally unfavorable circumstances produce beets that would not be accepted at a sugar factory.

The results of the analyses of beets grown by Wisconsin farmers during this season show that similar conditions did not prevail in all portions of the State. From three to four weeks after the beets were harvested the weather was most favorable to the maturing of beets, being sunshiny and quite warm, and, if the harvesting could have been postponed to this period, there can be no doubt that the results would have been nearly up to the standard set by earlier work in this line done at our experiment station. This would, however, have brought the harvest nearly a month and a half later than usual, which under ordinary fall conditions would be impracticable or at least quite inconvenient. The possible improvement of beets during the weeks following the harvest is suggested both by comparison with analyses of beets received from outside points before and after the time of our beet harvest and from what we know of the relations of weather conditions to the quality of the beets grown.

THE SOILS.

For the first time in the study of the effect of environment on the composition of the beet we have collected and examined a number of the soils on which the experiments were conducted. Unfortunately data on some soils are wanting, owing to the failure of the collaborating station to forward samples. The following data are therefore given tentatively, and in so far as possible the influence of the soil on the composition of the beets and the magnitude of the crop has been studied. The notes descriptive of the soils received from the stations follow on the next page.

DESCRIPTIVE NOTES ON SOILS.

Lafayette, Ind.

(Nos. 22383 and 22384.)

The samples of soil received from the Indiana station were accompanied by the following description:

I send you to-day a sample of the soil and a sample of the subsoil from the land on which the work on sugar beets will be conducted. This land has not been used for experimental plats, but has been in bulk crops, following the general rotation of corn, oats, wheat, and clover. Before the last corn crop I think there was millet on it. Last year the land was in clover with a poor stand, so that the beets are planted upon a clover sod which consists largely of weeds. The land is in the northwest corner of the field immediately west of the station building and is opposite the old greenhouse.

Agricultural College, Mich.

Field No. 3, Nos. 23581 and 23582.
Field No. 6, Nos. 23583 and 23584.

Under date of November 11, 1901, Mr. J. D. Towar, agriculturist of the station, made the following report on the soil on which the beets were grown:

In this mail I am sending you samples of the soil and subsoil on which the sugar beets which we have been sending you from seed No. 5772 were grown. The sample marked field No. 3 was a clover sod of two years' standing which was covered during the winter uniformly with a coat of stable manure. As soon as we could work the ground in the spring it was plowed to a depth of 8 inches and subsoiled 7 inches deeper. This operation was immediately followed by the roller, and the ground was harrowed at frequent intervals until May 9, when it was in fine condition, and an application of 200 pounds of home-mixed fertilizer per acre was made. This fertilizer consisted of one part nitrate of soda, one part muriate of potash, and two parts dissolved phosphate rock, the latter giving an analysis of about 17 per cent total phosphoric acid. The nitrate of soda was 96 per cent pure, and the muriate of potash contained 49.85 per cent K_2O.

The soil samples were taken August 28. In field No. 3 four samples of the soil were taken in the following manner, where the depths were respectively 9 inches, 8½ inches, 6½ inches, and 11½ inches. In each case a hole was dug about 1 foot square, leaving one perpendicular side from which a vertical slice about 3 inches in thickness was taken. The several samples were thoroughly mixed, and the sample sent is a portion of this mixture. The samples of subsoil, taken immediately below the soil samples, were from a depth of 1 foot, and were procured in a similar manner.

The samples from field No. 6 were taken in a similar manner to those from field No. 3, though the soil, a heavier loam, was from a plot which has grown sugar beets three years in succession, receiving absolutely no fertilizer. The depth of soil in the three places sampled was 8½, 8, and 9¼ inches. This plot was adjacent to others which have received each year applications of fertilizers, but the remarkably low yield of the No. 6 plot is due more to the lateness of the season at which the seed was planted than to exhaustion of the soil fertility. I wrote you some time ago that we had sown this seed on a piece of muck land, some of which was quite thoroughly mixed with alluvial soil.

Logan, Utah.

(No. 23586.)

The history of the plot used for the special beet work at the Utah station was reported as follows:

Plot No. 379 is located on the upper level of the Logan delta. The soil is gravelly and not more than 2 feet in depth. It is underlaid by a stratum of coarse porous gravel perhaps 25 feet or more in thickness. The virgin ground was broken in 1889. Corn was grown on it in 1890 and 1891, oats in 1892, clover in 1893, wheat in 1894, timothy in 1895 and 1896, wheat in 1897, peas in 1898, wheat in 1899 and 1900, and sugar beets, United States Department of Agriculture No. 5772 "special," in 1901. The plat was manured in the winter of 1900–1901.

Blacksburg, Va.

(No. 23818.)

The soil in which the beets were raised is described as a brownish-black loam. The following description of the taking of the sample forwarded to Washington for analysis and its general characteristics was furnished by the director of the station:

Three positions, fairly representing the entire plot, were chosen, and the notes made as follows:

Opening No. 1.—The soil down to the subsoil measured 7¼ inches, dark brown color, mellow loam in character. Color changed sharply at this point. Subsoil ocherous gray, quite friable, with considerable sand, yet firm.

Opening No. 2.—Same general character of soil; 9 inches down to the line of change of color.

Opening No. 3.—Soil 8½ inches to the line of change of color. The loam is a lighter brown in color. The subsoil is the same.

This land is a part of the experimental garden which was heavily manured until the last three years, during which time it had received no barnyard manure and no chemical fertilizers. It would be considered a very good type of garden soil, but in its present state is not very rich, as it has been cropped heavily each year. Last year on this area we grew a collection of Chinese vegetables, chiefly root crops, but no beets or crops belonging to this family.

Madison, Wis.

(Nos. 25051 and 25052.)

The history of the soil on which the sugar beets of 1901 were grown is as follows:

The plat set apart for the sugar beets at the university farm was a piece of land one-half acre in area (155 by 141 feet) in the northwestern portion of the Randall field. The field has been used as a pasture ever since this region was settled, and was in corn last year. During late years, prior to 1900, it served as a pasture for sheep or cows, but has never been otherwise manured. The soil is a clay loam, and, like most of the land on the university farm, has a tendency to bake after rains. The land produced a very good corn crop last year, and, as regards its state of fertility, should have been well adapted to the production of sugar beets. The lower part of the field slopes toward the northeast, and the unevenness in the soil in different parts of the field thus introduced rendered it somewhat unsatisfactory for variety tests.

Ithaca, N. Y.

(No. 25099.)

Unfortunately the sample of soil was not taken at Ithaca until 1902, and in the meanwhile a crop of oats and a crop of hay from clover and timothy had been harvested. The analysis of the sample of soil from the plat on which the beets were grown in 1901 is, however, submitted with the above explanation.

Ames, Iowa.

(No. 25114.)

The sample of soil from the plat on which the beets were grown in 1901 was not taken until 1902, and Mr. Atkinson, writing under date of October 28, 1902, in regard to this soil, says:

I may say that there was a crop of soy beans grown on this plat during 1902, but I have had samples of the soil of the first 6 inches, the second 6 inches, and the third 6 inches taken, and will forward them to you if you desire to have them now. Of course I understand that the soy beans will have produced a very marked effect on the soil, particularly on the amount of nitrogen present. However, I shall dry the samples and forward them to you, and hope that they may be of some use in compiling results.

The samples sent were so small that the three were mixed and one analysis made.

Potomac Flats, Washington, D. C.

(No. 25125.)

This soil is an alluvial silt pumped from the Washington harbor side of the Potomac River. It was first plowed in 1898, and has never been fertilized. In 1899 the plat lay fallow, and in 1900 it was in corn.

Lexington, Ky.

No sample was forwarded from this station, but the soil in which the experiments were conducted is described as the clay loam of the station farm known as bluegrass soil.

Geneva, N. Y.

No sample of soil was received from Geneva, but the following descriptive data were furnished, relating to the fertilizer experiments:

The general character of the soil was that of a clay loam. Comparative experiments were carried on with farm manure and commercial fertilizer, and for the first time in four years the beets raised on the plats to which the commercial fertilizer had been applied were superior to those on which stable manure had been applied.[a] This is

[a] For a full discussion of the work from this point of view see Bul. No. 205, N. Y. Exp. Sta., Influence of Manure on Sugar Beets, December, 1901.

attributed to the fact that an excessive amount of the latter was used. The analytical data obtained at Geneva bearing on this point is shown in the following table:

Agricultural and analytical data prepared at the New York Experiment Station, Geneva.

Fertilizer.	Quantity of fertilizer per acre.	Beets grown.				
		Average weight after topping.	Estimated yield per acre.	Sugar in juice.	Sugar in beets.	Purity coefficient.
	Pounds.	*Ounces.*	*Tons.*	*Per cent.*	*Per cent.*	
Stable manure	80,000	13.1	14.9	18.6	13.4	80.0
Commercial fertilizer	1,000	12.0	12.6	20.7	15.6	87.7
Average	.....	12.7	13.8	19.7	14.5	83.4

ANALYSES OF SOILS.

In the comparative table of analyses given below, including such stations as sent samples of soil, two methods of examination were employed, namely, the method of the Association of Official Agricultural Chemists,[a] and the method of ascertaining the quantity of mineral matter soluble in N/200 hydrochloric acid, as proposed by C. C. Moore, of the Bureau of Chemistry.[b] The first method gives practically all of the mineral matter in the soil that may become available in many years. The second method represents an attempt to determine the quantity of mineral matter (in this case potash and phosphoric acid only) which is available for the immediate uses of a crop. The method has been developed, however, with special reference to the oat plant. A glance at the analytical data obtained shows a wide difference in the character of these soils, both in respect of the total amount of plant food eventually available and the amount immediately available.

Chemical analyses of sugar-beet soils, 1901.

Station.	Soil sample.		Insoluble matter.	Water (H_2O).	Volatile.	Nitrogen (N).	Soluble in N/200 hydrochloric acid.	
	Serial number.	Description.					Potash (K_2O).	Phosphoric acid (P_2O_5).
			Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Lafayette, Ind.	22383	Soil	79.40	1.60	8.83	0.295	.0074	.00017
	22384	Subsoil	78.74	1.92	8.00	.239	.0051	.00014
Agricultural College, Mich.	23581	Soil (field No. 3)	91.87	.28	3.62	.154	.0036	.000062
	23582	Subsoil (field No. 3)	92.03	.24	2.44	.091	.0102	.00017
	23583	Soil (field No. 6)	91.87	.46	4.30	.161	.0052	.00009
	23584	Subsoil (field No. 6)	93.59	.26	2.08	.070	.0039	.00015
Logan, Utah	23586	Soil	71.54	1.26	10.75	.201	.0333	.00143
Blacksburg, Va.	23818		89.00	.42	4.46	.154	.0198	.00003
Madison, Wis.	25051	Soil	82.77	6.50	4.45	.165	.0040	.00040
	25052	Subsoil	79.81	5.20	4.40	.105	.0027	.000025
Ithaca, N. Y	25099	Soil	78.86	8.24	5.50	.201	.0077	.00003
Ames, Iowa	25114	.....do	78.49	2.82	8.45	.267	.0079	.00020
Washington, D. C.	25125	.....do	83.47	1.75	5.35	.183	.0062	.00020

[a] Methods of Analysis, Bul. 46, Revised, Bureau of Chemistry, U. S. Dept. Agr.

[b] Journal American Chemical Society, *24*, 79.

Chemical analyses of sugar-beet soils, 1901—Continued.

Station.	Soil sample.		Soluble in 1.115 sp. gr. hydrochloric acid.					
	Serial number.	Description.	Sulphuric acid (SO_3).	Potash (K_2O).	Lime (C_aO).	Magnesia (MgO).	Fe_2O_3 Al_2O_3 Mn_3O_4.	Phosphoric acid (P_2O_5).
			Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Lafayette, Ind	22383	Soil	0.09	0.85	0.60	0.60	8.49	0.12
	22884	Subsoil	.06	.36	.72	.62	9.83	.10
Agricultural College, Mich.	23581	Soil (field No. 3)	.07	.12	.46	.32	3.33	.06
	23582	Subsoil (field No. 3)	.09	.18	.43	.45	4.60	.03
	23583	Soil (field No. 6)	.06	.06	.34	.22	3.30	.06
	23584	Subsoil (field No. 6)	.03	.13	.32	.35	3.61	.04
Logan, Utah	23586	Soil	.07	.76	5.00	3.42	7.49	.24
Blacksburg, Va	23818		.07	.80	.14	.29	5.57	.10
Madison, Wis	25051	Soil	.....	.35	.87	.59	4.42	.04
	25052	Subsoil	.....	.38	.52	.75	9.82	.06
Ithaca, N. Y	25099	Soil	.09	.22	.16	.56	6.55	.13
Ames, Iowa	25114	do	.....	.35	.85	.65	8.22	.06
Washington, D. C	25125	do	.....	.39	.47	.51	8.27	.03

Mechanical analyses of sugar-beet soils, 1901.[a]

Station.	Soil sample.		Fine earth.							
	Serial number.	Description.	Organic matter.[b]	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
Lafayette, Ind	22383	Soil	3.52	1.94	4.00	2.22	2.00	5.76	62.08	22.00
	22384	Subsoil	3.00	1.37	3.12	2.06	1.72	5.35	58.23	18.15
Agricultural College, Mich.	23581	Soil (field No. 3)	1.62	2.84	6.76	12.20	34.54	15.84	18.22	8.86
	23582	Subsoil (field No. 3)	.54	2.78	5.32	11.60	37.60	14.96	13.26	13.86
	23583	Soil (field No. 6)	1.73	5.18	7.58	14.86	41.76	9.64	13.70	7.24
	23584	Subsoil (field No. 6)	.80	4.84	6.80	14.58	44.06	10.66	11.04	7.12
Logan, Utah	23586	Soil	3.24	.62	1.90	1.84	15.48	27.62	25.26	26.62
Blacksburg, Va	23818	do	2.07	2.68	3.84	4.68	9.62	12.66	48.10	18.00
Madison, Wis	25051	do	2.41	.48	1.46	2.26	6.36	11.82	64.12	13.36
	25052	Subsoil	.68	.....	.46	.94	3.68	10.52	69.46	14.76
Ithaca, N. Y	25099	Soil	2.09	6.10	4.78	3.74	10.30	16.26	38.88	19.98
Washington, D.C.	25125	Soil (from flats)	1.63	.34	1.52	2.94	16.78	24.00	33.02	21.40

[a] Made in the Bureau of Soils, U. S. Department of Agriculture.
[b] Organic matter determinations were made by the wet combustion method.

COMMENT ON ANALYSES.

The study of the analytical data in the above tables is interesting from a scientific point of view, and is also conclusive, in so far as one series of observations can be, in regard to the very small effect which the composition of the soil has upon the sugar content of the beet. While it is doubtless true that the character of the soil influences to a greater or less degree the quality of some crops, it is certain that its principal influence in the case of the sugar beet is exerted almost exclusively upon the magnitude of the crop. In this connection the writer would like to recall from personal experience two instances

showing how widely different kinds of soil may produce beets which have practically the same content of sugar. A few years ago samples of beets were received from Chautauqua County, N. Y., which were grown in a reclaimed swamp where the drainage had been so perfected as to permit the cultivation of the soil. The beets grown in this soil, extremely rich in vegetable mold, had a very high content of sugar. On the other hand, samples of beets taken from almost a pure sand near the Kankakee River in Indiana, where there was scarcely any organic matter in the soil, had almost the same content of sugar. These two types of soil were as entirely different as can well be imagined.

RELATION OF CROP TO THE PHYSICAL PROPERTIES OF THE SOIL.

Among the physical properties of the soils in question, determined for us by the Bureau of Soils of this Department, the first to be considered is the content of clay. The soil having the lowest amount of clay was that from field No. 6, Agricultural College, Mich., 7.24 per cent. Low clay content is usually associated with a high percentage of sand, and such is the case in this instance, the total sand of all dimensions being nearly 75 per cent. The highest clay content is found in the sample from Utah, namely, 26.62 per cent. This, of course, would indicate a low percentage of sand, which, in point of fact, is only about 45 per cent. The percentages of clay in the three soils producing the beets with the highest content of sugar (about 14.6 per cent in each case) were as follows: In the sample from Agricultural College, Mich. (field 3), 8.86 per cent; in that from Ithaca, N. Y., 19.98 per cent, and in that from Lafayette, Ind., 22 per cent, while the soil producing the poorest beets, namely, Washington, D. C., had 21.4 per cent of clay. It is evident from a study of the figures grouped in the following table that, while the texture of the soil, as shown by the mechanical analysis, undoubtedly has a direct bearing on the yield per acre, it has practically no effect on the content of sugar in the beet:

Mechanical analyses of soils and data regarding the crops of sugar beets grown thereon.

Serial number.	Station.	Sugar-beet crop.		Mechanical analyses of soils.		
		Sugar content.	Yield per acre.	Clay.	Silt.	Total sand.
		Per cent.	*Tons.*	*Per cent.*	*Per cent.*	*Per cent.*
25125	Washington	8.5	8.1	21.40	33.02	45.24
25061	Madison, Wis	12.7	11	13.36	64.12	21.90
23818	Blacksburg, Va	13.1	10	18	48.10	30.80
22383	Lafayette, Ind	14.6	[a]5.4	22	62.08	13.98
25099	Ithaca, N. Y	14.6	12.6	19.98	38.88	35.08
23581	Agricultural College, Mich.[b]	14.7	15.1	8.86	18.22	69.34

[a] Only one estimate.

[b] Field No. 3.

In considering the effect of the chemical composition of the soil upon the character and magnitude of the crop we have a problem of intricate difficulties. If we regard the soil in the light of the total plant food contained therein as indicated by treatment with hot concentrated hydrochloric acid for a considerable period of time we introduce figures which must be foreign to the problem in question. In point of fact, in order to have any accurate conception of this problem it is necessary to differentiate the amount of any given plant food consumed by a given crop from the total supply which is present. This might be illustrated by an attempt to determine how much nourishment would be given a man of average size during a day by analyzing the total nourishment in a barrel of flour from which his day's supply of bread has been made. The actual effect produced upon the man would not be represented by the total amount of flour in the barrel, but only by the total amount of flour he consumed. Therefore, as before stated, in considering the influence of the composition of the soil upon that of the beet and the magnitude of the crop it is important to know first the total quantity of plant food present, and next to ascertain if possible what portions are immediately available for the use of the crop. The following table has been arranged in order that the interrelations of these factors may be more conveniently observed:

Chemical analyses of soils and data regarding the crops of sugar beets grown thereon.

Serial number.	Station.	Sugar-beet crop.		Chemical analyses of soils.				
		Sugar content.	Yield per acre.	Nitrogen.	Potash.		Phosphoric acid.	
					Total.	Available.	Total.	Available.
		Per cent.	*Tons.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
25125...	Washington.....	8.5	8.1	0.183	0.39	0.0062	0.03	0.00020
25051...	Madison, Wis.....	12.7	11.0	.165	.35	.0040	.04	.00040
23818...	Blacksburg, Va	13.1	10.0	.154	.80	.0198	.10	.00003
22383...	Lafayette, Ind	14.6	[a] 5.4	.295	.35	.0074	.12	.00017
25099...	Ithaca, N. Y.....	14.6	12.6	.201	.22	.0077	.13	.00003
23581...	Agricultural College, Mich.[b]	14.7	15.1	.154	.12	.0036	.06	.00062

[a] One estimate only.

[b] Field No. 3.

Our studies of this problem are too restricted to justify any conclusion at present further than to call attention again to the patent fact that the quality of this crop is affected only in a minor degree by the chemical and physical properties of the soil. The case is quite different in respect to the kind of crop best suited to a given soil and the magnitude of the harvest. These two items are intimately associated both with the texture of the soil and the quantity of plant food therein.

SUMMARY OF DATA.

Summary of agricultural and analytical data, 1901.

Station.	Mean weight of topped beets.	Estimated yield per acre.	Sugar in beet.	Coefficient of purity.
	Ounces.	*Tons.*	*Per cent.*	
Washington, D. C	7.9	8.1	8.5	67.3
Lexington, Ky.[a]	10.4	8	9	71
Madison, Wis	10.9	11	12.7	77.4
Blacksburg, Va	4.5	10	13.1	77.6
Ames, Iowa	14.2	12.9	14.1	80.2
Logan, Utah	24.2	23.4	14.2	79.1
Agricultural College, Mich	[b] 8.3	[b] 10.2	14.6	81.5
Lafayette, Ind.[a]	8.2	[c] 5.4	14.6	82.5
Ithaca, N. Y	13.1	12.6	14.6	79.9
Geneva, N. Y	17.2	13.8	15.8	83.9

[a] One sample analyzed at Washington.
[b] Average of late and early planting; data for early planting gives average weight 10 ounces, and average yield 15.1 tons.
[c] One estimate, for November 1, 1901.

Summary of meteorological data, May to October, 1901.

Station.	Mean temperature.	Precipitation.	Clear days.	Cloudy days.	Sunshine.
	°*F.*	*Inches.*			*Per cent.*
Washington, D. C	69	19.34	81	49	64
Lexington, Ky	69.3	16.23	95	18	75
Madison, Wis	65.6	14.33	48	66	----------
Blacksburg, Va	63.8	32.08	79	53	[a] 53.7
Ames, Iowa	67.9	16.15	127	19	[b] 69.85
Logan, Utah	64	7.37	130	37	[c] 76.3
Agricultural College, Mich	62.8	19.84	96	37	[d] 61.8
Lafayette, Ind	68.6	16.41	74	52	[e] 69.85
Ithaca, N. Y	63.4	17.44	49	54	66
Geneva, N. Y	65.5	18.03	See Ithaca.		

[a] Average of weekly data furnished by Blacksburg station.
[b] Observed at Des Moines.
[c] Observed at Salt Lake.
[d] Sunshine record for Detroit.
[e] Observed at Indianapolis.

Summary of geodetic data for experiment stations.

Station.	Average length of day.[a]	Latitude.[b]	Altitude.[b]
	h. *m.*	° ′ ″	*Feet.*
Washington, D. C	14 23	38 53 23	37.5
Lexington, Ky	14 18	38 02 25	979
Madison, Wis	14 44	43 04 36	955
Blacksburg, Va	14 14	37 14 00	2,100
Ames, Iowa	14 38	42 02 00	917
Logan, Utah	14 37	41 44 00	4,506
Agricultural College, Mich.[c]	14 42	42 45 00	847
Lafayette, Ind	14 30	40 23 00	542
Ithaca, N. Y	14 41	42 27 00	810
Geneva, N. Y	14 44	42 53 00	453

[a] These figures are for May to August, inclusive, and are from the records of the U. S. Naval Observatory.
[b] Data furnished by the U. S. Coast and Geodetic Survey.
[c] Determinations for Lansing, Mich.

CONCLUSIONS.

As in the previous report on this subject, the data obtained in the studies described in the previous pages are for convenience platted graphically in three charts, figs. 1, 2, and 3.

Chart No. 1 shows the percentage of sugar in the beet, the latitude of the station, and the sunshine record, including the total percentage and its distribution. The plat is based upon the percentage of sugar in the beets, beginning with the station having the lowest record and ending with that having the highest. Since North Carolina has dropped out of the list of stations cooperating, Washington enjoys the distinction of having produced beets with the lowest content of sugar. In order of sugar content, the other stations are arranged in an ascending scale, as follows: Lexington, Madison, Blacksburg, Ames, Agricultural College, Lafayette, Ithaca, and Geneva.

In general it may be seen that the latitude, as in the first year's experiments, follows the sugar content. A notable exception to this is found in the case of Blacksburg. The reason of this exception has been stated, namely, the great altitude of the Blacksburg station. This fact, for the illustration of which the Blacksburg station was especially selected, indicates that, in platting the latitude curve, some method of reducing it to sea level should be introduced. Just what method is best suited for this purpose can not be stated or even suggested. It is evident, however, that this is a problem which must receive due consideration, and that this calculation must be a special one for each case. For instance, the effect of altitude on temperature on a mountain plateau like that of Blacksburg would be very different from the effect of the same altitude upon the temperature on a vast plain like that extending around Ames, Iowa, or even Lexington, Ky. These problems are of the utmost meteorological and scientific import, and the depression in the curve of latitude, as illustrated in this chart by the Blacksburg station, is of the greatest interest. Eliminating this one point, it will be seen that the content of sugar varies practically with the latitude, the only other exception to this being the data from the Lafayette station, which from the first of the collaborative studies have been found to be very erratic.

The curve showing the percentage of sunshine is broken, because no data for the Madison station is procurable. Kentucky, as will be seen, had the maximum percentage of sunshine platted, namely, 75 per cent. The lowest percentage of sunshine was that of the Blacksburg station, namely, 53.7 per cent. The next highest was that of the stations at Ames and Lafayette, they having the same percentage, namely, 69.9 per cent. The percentage of sunshine seems to have but little effect upon the sugar content, and it appears to be well established that the chemical activities of the sun's light, in promoting the condensation

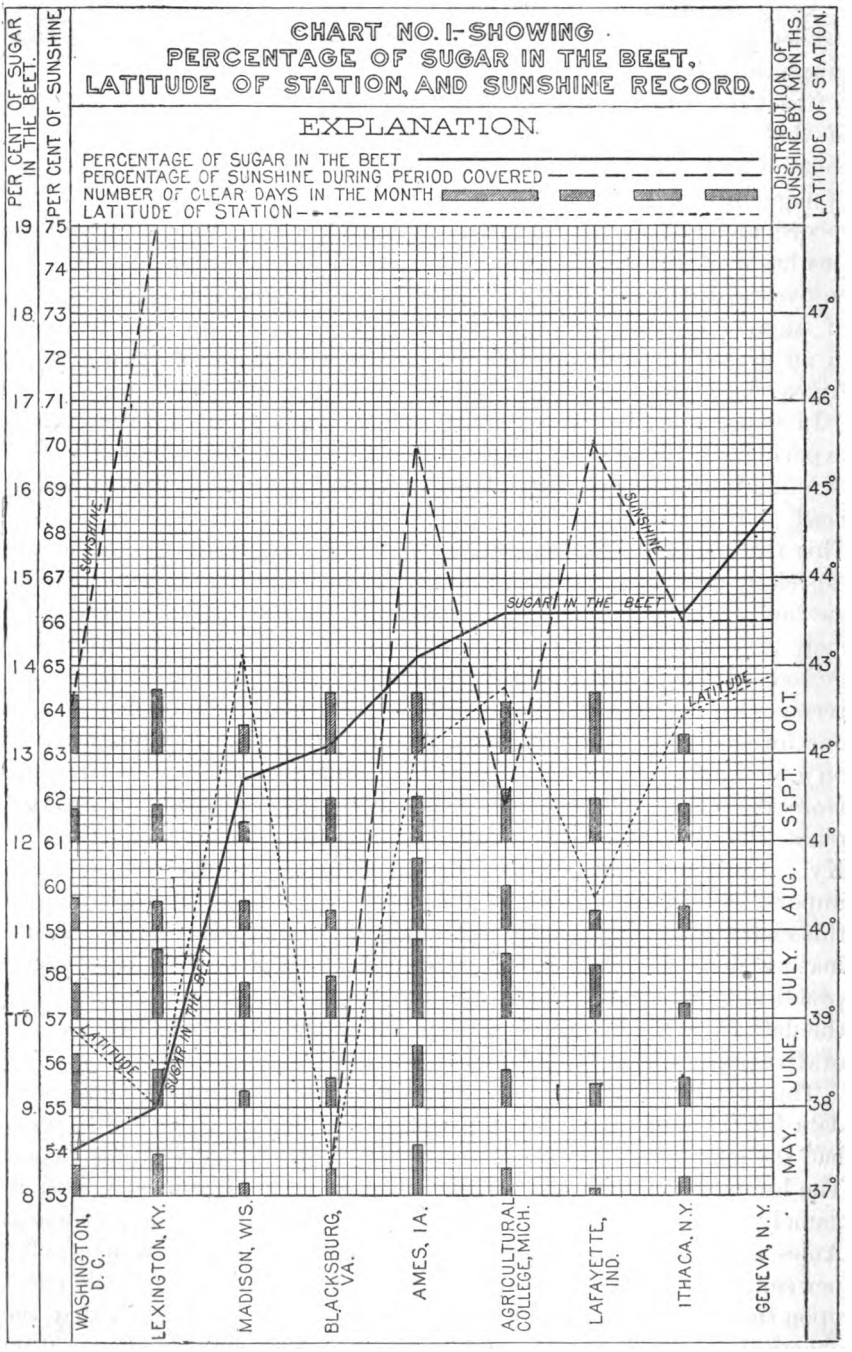

FIG. 1.—Showing percentage of sugar in the beet, latitude of station, and sunshine record.

of carbohydrate molecules in the chlorophyll cells, are not notably diminished by filtration through aqueous vapor.

The distribution of the sunshine as indicated by the number of clear days in each month is also an interesting part of the problem. From the chart, Washington and Ames appear to have had the most uniform distribution of clear days—that is, the number was quite uniform for each month. The smallest number of clear days was experienced at Madison; especially is this true of May, June, and September. The largest number of clear days was experienced at Ames, July and August being conspicuous in this particular. Ithaca stands next to Madison in regard to the small number of clear days, having almost the same record. As in the case of sunshine, it must be said that the actual predominance of clear days is not to be reckoned as an important factor, except in so far as it may indicate drought, and thus interfere with the magnitude of the crop. Thus the large number of clear days at Ames was accomplished by excessively dry weather in 1901.

Chart No. 2 shows the percentage of sugar in the beet, the purity of the juice, the temperature, and the average length of day at the station. The most interesting feature of this chart is the relation between the average length of day and the sugar in the beet. Eliminating, as in the case of latitude, the Blacksburg station, where the days, on account of the southern latitude, were short, and ignoring the slight variation at Lafayette, we find that there is a general agreement in the direction of the two curves, representing the percentage of sugar in the beet and the length of the day. In other words, it may be generally stated, as the result of an inspection of this chart, that the percentage of sugar in the beet increases with the length of the day. This is in harmony with the commonly accepted theory of the correlation of the functional activity of the chlorophyll cells and the light of the sun. Under the same general conditions it is evident that the longer the hours of activity the greater the amount of work accomplished; hence, with longer hours of sunlight the quantity of carbohydrates formed will be greater.

The temperature curve, as in chart 2 of Bulletin 64, crosses the curve of sugar content, but not symmetrically, as in the chart just mentioned. One reason of this lack of symmetry is the low temperature of the Blacksburg station. On the other hand, a phenomenally high temperature is recorded for the Lafayette station. While showing more irregularities than the curves representing latitude and length of day, it is yet evident that the tendency of the sugar is to diminish as the temperature increases. The purity curve, as was to be expected, follows in general the percentage of sugar in the beet.

Chart No. 3 shows the percentage of sugar in the beet, the altitude of the station, and the rainfall record, both the totals and the distribution by months.

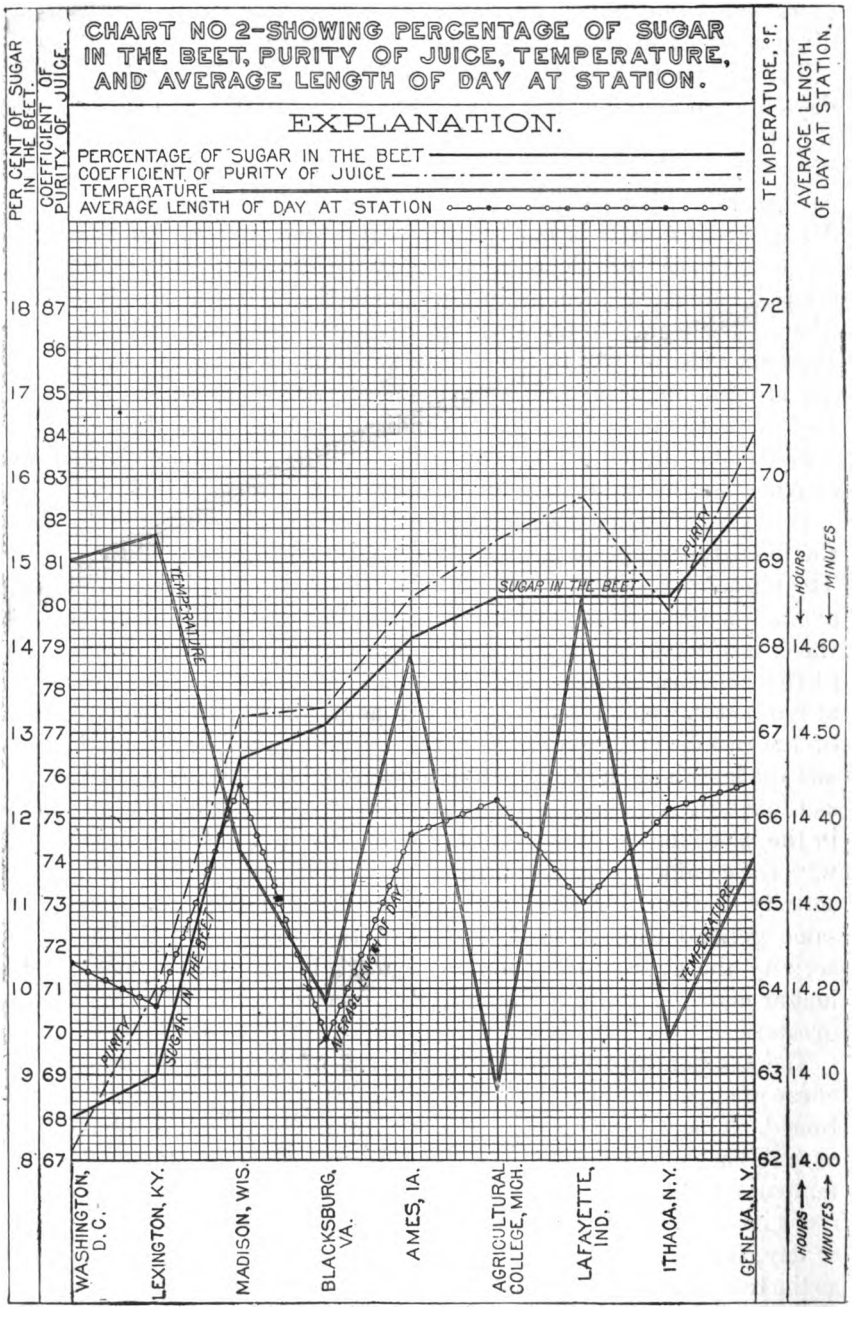

FIG. 2.—Showing percentage of sugar in the beet, purity of juice, temperature, and average length of day at station.

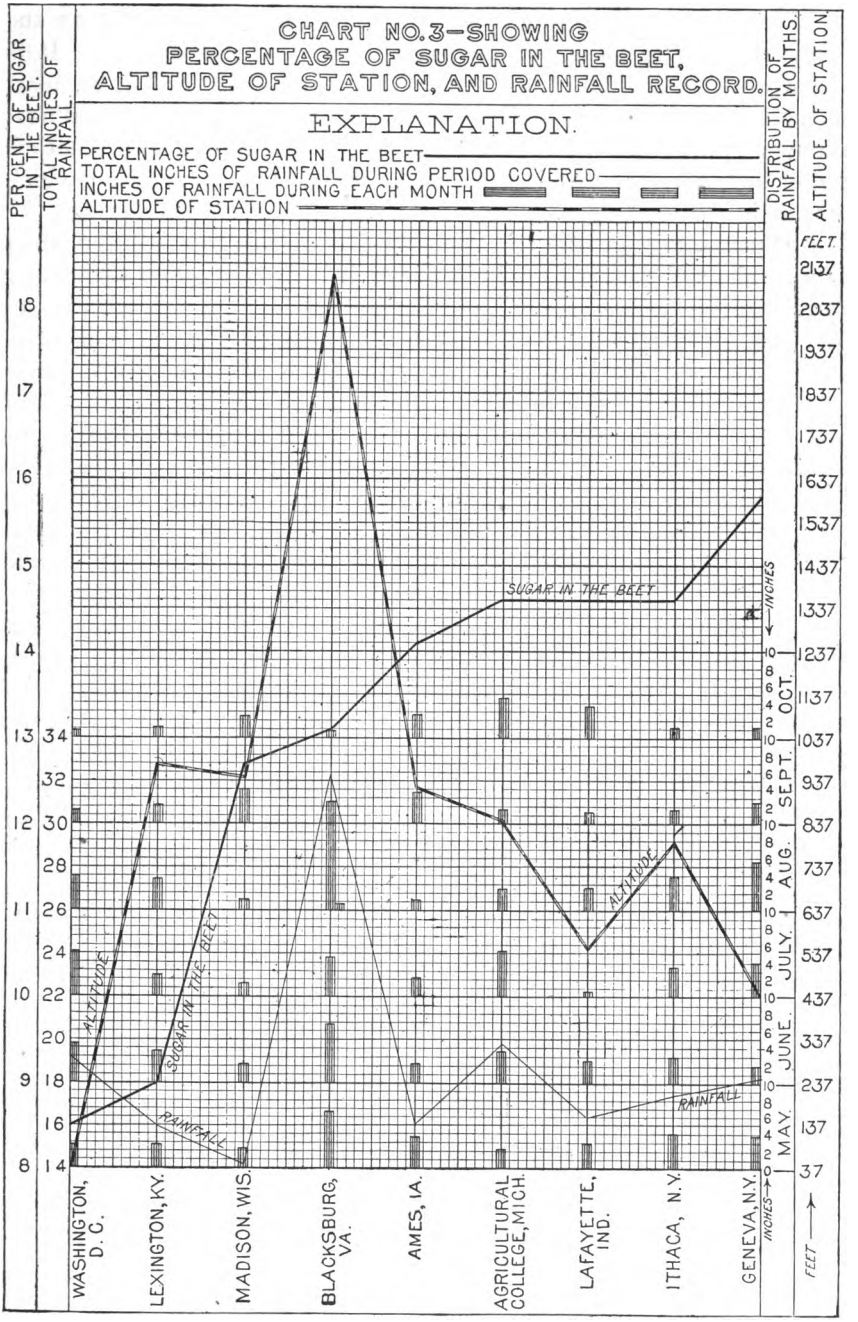

Fig. 3.—Showing percentage of sugar in the beet, altitude of station, and rainfall record.

The remarkable curve showing the altitude of the Blacksburg station is first to be noted. No more striking effect of environment on the composition of the beet could be given than that shown here. It is the altitude in this case which has secured so high a content of sugar in the beet. This station, which has the lowest latitude, shows almost the mean percentage of sugar found at the other stations. Another important effect of altitude is shown at the Washington station, which is practically at sea level, where the lowest altitude coincides with the lowest percentage of sugar. The only proper way to study the effect of altitude, as has already been intimated, is in connection with other physical features of the environment, such as mountain ranges, broad and extensive plateaus, etc. Altitude evidently does not in every case tend to increase the content of sugar. This is illustrated in the case of Ithaca and Geneva. Ithaca is almost 400 feet higher than Geneva and yet the sugar content of the beets grown at Geneva in the two seasons covered by this experiment has been higher than at Ithaca.

The rainfall, as is shown by the curve, was smallest at Madison. Other areas receiving a small rainfall were Ames, Lafayette, and Lexington. The greatest amount of rainfall was at Blacksburg, and the next greatest at Agricultural College, Mich., and at Washington. The actual amount of rainfall does not have so great an influence on the composition of the beet as does its distribution. It has been shown that excellent beets can be produced with a rather deficient supply of rain, as was the case at Madison, at Ames, and at Lafayette. On the other hand, an excessive amount of rain is not necessarily destructive of sugar content, as is illustrated by the plat at the Blacksburg station. In other words, it may be stated that, given a sufficient quantity of water to secure normal growth, the beet is not very sensitive either to a slightly diminished or a slightly increased supply. It is important, however, that the rainfall be not too great in September, which is the period of ripening, nor in October, the season of harvesting.

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U. S. DEPARTMENT OF AGRICULTURE.

BUREAU OF CHEMISTRY—BULLETIN NO. 78.

H. W. WILEY, CHIEF.

THE INFLUENCE OF ENVIRONMENT

UPON THE

COMPOSITION OF THE SUGAR BEET, 1902,

INCLUDING A STUDY OF IRRIGATED SECTIONS.

BY

HARVEY W. WILEY,

CHIEF OF BUREAU,

IN COLLABORATION WITH THE WEATHER BUREAU AND THE AGRICULTURAL EXPERIMENT STATIONS OF CALIFORNIA, COLORADO, INDIANA, KENTUCKY, MICHIGAN, NEW YORK, UTAH, VIRGINIA, AND WISCONSIN.

WASHINGTON:

GOVERNMENT PRINTING OFFICE.

1903.

LETTER OF TRANSMITTAL.

U. S. DEPARTMENT OF AGRICULTURE,
BUREAU OF CHEMISTRY,
Washington, D. C., June 30, 1903.

SIR: I have the honor to transmit for your approval a manuscript, accompanied by graphic charts, embodying the results of the cooperative work conducted by this Bureau on the study of the effect of environment upon the composition of the sugar beet during the year 1902, and to recommend its publication as Bulletin 78 of the Bureau of Chemistry. This is a continuation of the work of 1900, the results of which were published in Bulletin 64, and of 1901, reported in Bulletin 74.

In this connection I desire to express the appreciation of this Bureau of the collaborative work done by the various experiment stations taking part in the experiment; of the continued cooperation of the Weather Bureau, without which it would be very difficult, if not impossible, to collect the meteorological data; and of the information furnished by the United States Coast and Geodetic Survey and the Naval Observatory. The analytical work done in this Bureau on the beets was performed by Messrs. Houghton and Given; that on the soils by Messrs. Veitch and Trescot; while the mechanical analyses were made by the Bureau of Soils.

Respectfully,

H. W. WILEY, *Chief.*

Hon. JAMES WILSON,
Secretary of Agriculture.

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THE INFLUENCE OF ENVIRONMENT UPON THE COMPOSITION OF THE SUGAR BEET, 1902.

ORGANIZATION OF COLLABORATIVE WORK.

In the third year of the cooperative experiments with the sugar beet two series of experiments were conducted, one with stations where irrigation was practiced and the other with the nonirrigated stations at which the work has been carried on for two years. The consideration of the soils in which the beets were grown, which was begun in a tentative manner in 1901, was continued and a more complete study was made of this phase of the environment, two additional charts being added to show the relation of the more important plant foods and the physical condition of the soil to the yield per acre.

On February 28, 1902, the following letter was sent to the stations at Logan, Utah; Fort Collins, Colo.; Mesilla Park, N. Mex.; Tucson, Ariz.; Laramie, Wyo.; Moscow, Idaho; Berkeley, Cal.; Pullman, Wash., and Corvallis, Oreg., at which irrigation would probably be practiced:

DEAR SIR: It is desirable to extend the studies of the influence of environment on the constitution of the sugar beet to areas where irrigation is practiced. The scope of these studies and the methods of conducting them are sufficiently outlined in Bulletin 64 of this Bureau, a copy of which is inclosed.

I desire to have your cooperation in these studies and feel very sure that great good will come of them, not only to the beet-sugar industry, but to agriculture in general. The extent of the collaboration is sufficiently shown in Bulletin 64. If you are willing to engage in these collaborative studies, I beg you to inform me at an early date. The necessary seeds for planting and uniform directions for culture and irrigation will be prepared and forwarded as soon as your acceptance is received. I send this letter with the full approbation of Mr. Elwood Mead, in charge of the irrigation work of the Department of Agriculture, who would have joined me in the signature had he not been absent from the city.

Respectfully, H. W. WILEY, *Chief.*

Of the stations to which this letter was sent, five—namely, those of Utah, Wyoming, California, Colorado, and Idaho—consented to take part in the experiment. Only three reports are given, however, as the Wyoming crop was a failure and the work done at the Idaho station was not comparable with the other experiments, no irrigation being practiced. The request reached the Arizona station too late in the season for acceptance.

To the stations which had previously cooperated in the work, namely, those of North Carolina, Iowa, Michigan, Virginia, Indiana, Wisconsin, Kentucky, and the two New York stations, the following letter was sent:

MARCH 7, 1902.

DEAR SIR: The good results which have attended the collaborative work in the study of the effect of environment upon sugar beets, and the high commendations thereof which have been received from many practical sources, lead me to believe that a continuance of this work would be highly beneficial. The Weather Bureau has promised to continue its collaboration, and I desire to ask you to undertake again work similar to that which you have done in this direction the past two years. Seeds of high grade and with a germinating power of high quality, as tested in this Department, will be sent to you, as heretofore, for experimental work. The character of the experiments is sufficiently outlined in Bulletin 64, a copy of which I send inclosed.

Hoping that I may have a favorable reply, I am,

Respectfully, H. W. WILEY, *Chief.*

The North Carolina station, which had withdrawn from the work in 1901, was again unable to cooperate, and the work was also temporarily discontinued at Ames, Iowa, on account of a change in the station force.

The following letter containing complete instructions as to the conduct of the experiment, the sampling of the soil, records to be kept, etc., together with an additional note for the stations practicing irrigation, was sent to all cooperating stations at the opening of the season:

APRIL 15, 1902.

DEAR SIR: For the collaborative work in the study of the influence of environment on the composition of the sugar beet, for the present year, I have decided to use seed No. 8238, and a package of this number has been sent to you for such collaborative work.

The area planted need not exceed an eighth of an acre, unless you desire a larger area or a number of plats. This matter is left entirely to your own judgment, and the residue of the seed you can dispose of as you like. I suggest, however, that the special plat be seeded very heavily so as to be sure of a good stand, and that enough of the seed be reserved for replanting in case the first planting should not germinate.

The soil some time before sowing, preferably the previous autumn, should be plowed to the usual depth of 8 or 9 inches and subsoiled to at least 6 inches more, making a seed bed of at least 15 inches in depth. If the character of the soil warrants it, a deeper plowing, even to 10 or 11 inches, and a subsoiling of 6 inches additional, will be advisable.

The surface of the soil should be reduced to a fine tilth and well harrowed and stirred immediately before planting so as to stop all growth of weeds which may have started. The rows should be 18 inches apart and the seed planted at the rate of about 25 pounds per acre, so as to be sure of a good stand. If the soil be moist the seed should be covered to a depth of from one-half to 1 inch. If the weather be dry, slightly deeper planting may be advisable.

As soon as the plants are vigorously growing, they should be "bunched" by a hoe 6 inches in width, leaving the length of 3 inches of beets in each hill. When the beets have a vigorous growth and begin to form the fourth leaf, they should be thinned to about one plant in each 9 inches. Where vacancies occur in a row, transplant carefully so as to have the number of plants indicated.

Ordinary surface cultivation is all that is required, being careful not to cover up the beets at the first cultivation.

In connection with this study, I desire to make careful chemical and physical analyses of the soils of the plats used for the growing of the beets. I therefore ask that you take a representative sample of the soil and subsoil of the plat on which you grow the No. 8238 seed during the present year. After getting a representative sample reduce it in size by quartering or otherwise so as to secure a representative subsample weighing not more than 4 pounds, and send it, under the inclosed frank, by mail to my address.

In sending the sample of soil in accordance with the above instructions, do not forget to send a history of the plat so far as known. Complete cultural and meteorological data, in collaboration with the Weather Bureau, should be kept and forwarded with the samples. Franks for forwarding the samples and full instructions for sampling and harvesting will be sent later. It is earnestly requested that frequent analyses be made at the station, so that the results of those analyses can be compared with those which are made of the beets sent here.

Any questions in regard to further details will be promptly answered.

Respectfully,

H. W. WILEY, *Chief.*

The note to the stations using irrigation was as follows:

IRRIGATED PLATS.

If irrigation is practiced it is desirable that a record be kept of the number of times water is applied and the amount used each time.

In regard to the details of irrigation I can not offer any suggestions, since I have had no experience whatever with irrigated plats. It appears to me that the important thing is to secure the regular and uninterrupted growth of the beets until maturity or near maturity, so that they can ripen without any danger of undergoing a second growth.

In these experiments the temperature record is of more than ordinary importance, since there is some ground for believing that a beet of excellent sugar content can be produced under irrigation where the mean temperature is much higher than is favorable to the production of a good beet in regions under ordinary cultivation.

Since this is the first collaborative experiment in this country undertaken in irrigated areas, suggestions for the second year's work are respectfully solicited.

The seed used in this experiment, referred to as S. P. I. No. 8238, was the Kleinwanzlebener Nachzucht, produced by H. Bennecke & Son, at Athensleben bei Löderburg, Germany, and transmitted to this Department through Ernst Anders, of Magdeburg, for use in this experiment. Mr. Anders, in transmitting the seed, said:

The high germinating power is a very important thing, guaranteeing a quick and equal start, regular growth, and finally a high tonnage. Please take in consideration that the sugar produced per acre will be increased to a very high amount by this fact, notwithstanding the percentage of sugar in the beets may be a little smaller in comparison with other high-grade beet seed giving a smaller tonnage. * * *

Furthermore, the power to germinate very quickly is very important in cases of destruction of the small plants by insects, or if the preparation of the fields is not finished in the proper time, as in either case a late drilling becomes necessary.

The germinating tests of the seed made in the laboratory of Seed and Plant Introduction, Bureau of Plant Industry, of this Department,

gave a germination of 80 per cent of seed balls, 196.5 sprouts from 100 seed balls, with 106,000 sprouts from 1,000 grams of seed, thus fully justifying the remarks of Mr. Anders concerning its vitality.

When the time for harvesting approached the following letter was addressed to the cooperating stations:

SEPTEMBER 9, 1902.

DEAR SIR: We are about to begin our analytical work on samples of sugar beets grown from the special seed No. 8238. This is the seed that I requested you to plant for the collaborative work in a study of the influence of environment on the composition of the beet. If practicable I would like you to follow the plan outlined below in obtaining samples of beets.

Harvest every beet in 50 feet of an inside row; wash, dry, and weigh the beets after removing the leaves, but not the crown or neck. Report the estimated yield per acre based upon the weight of the beets (not topped) from 50 feet of row. Forward to this Bureau by express, charges collect, about twenty-five average beets (not topped) from those harvested. Please weigh the beets before shipment, that we may calculate the loss in weight during transit to Washington. We shall use your estimated tonnage and the percentage of loss in topping in estimating the net yield per acre.

Please repeat this work every week until the end of the season. An identification slip giving date, name of station, and the weights and data requested above should be inclosed with each sample. With the first sample forward agricultural data.

Begin sampling on receipt of this letter, not awaiting full maturity of the beets. From time to time I will report the results of the analyses of the samples to you.

Trusting that it will be convenient for you to continue the cooperative work as outlined above, I am,

Respectfully, H. W. WILEY, *Chief.*

To distant stations cooperating in the work the following additional suggestions were made:

Since your experimental fields are so far from our laboratory, I would be very glad if you could arrange to have these analyses made at your station. If you can not do this, it will be necessary to subsample the beets harvested, report the agricultural data, and pack a carefully weighed quantity of untopped beets in a box and ship them to this laboratory, reporting the weight shipped. In this event about twenty beets should be sent.

I trust that it will not be necessary to forward these samples, as the results will be much more satisfactory if obtained with the fresh material at your laboratory.

These data should be obtained from the beets grown on both the irrigated and non-irrigated plats.

EXPERIMENTS CONDUCTED IN HUMID REGIONS.

POTOMAC FLATS, WASHINGTON, D. C.

Two series of experiments were carried on at the Department farm, Potomac flats. Each consisted of four plats, with dates of planting varying from April 18 to May 30, and in one series irrigation was practiced. The cultural data, except as to irrigation, were the same for both series of plats and are given as follows:

Plat 1.—Planted April 18; up April 22; thinned to two in a hill April 28, 29; thinned to one in a hill on May 14. The plat was cultivated with a wheel hoe on April 25, May 2, 8, 16, 26, June 12, and June 25, when the crop was laid by.

Plat 2.—Planted May 2; up May 8; thinned to two in a hill May 16; thinned to one in a hill May 24. The plat was cultivated on May 16, 26, June 12, 25, 30, and July 2, when the crop was laid by.

Plat 3.—Planted May 16; up May 20; thinned to one in a hill June 6. The plat was cultivated on May 26, June 6, 12, 18, 25, 30, July 5, and July 11, when the crop was laid by.

Plat 4.—Planted May 30; up June 10 (up where irrigated June 5); thinned to one in a hill June 24. The plat was cultivated on June 12, 18, 25, 30, July 5, and July 11, when the crop was laid by.

Each plat or planting consisted of 12 rows, each 25 rods long. The seeds were run in with a seed drill having the dropping attachment set to 9 inches, the rows being 18 inches apart. The plants were thinned as soon as the seedlings were large enough to handle.

The following record shows the amount of moisture received by the irrigated plats from both rainfall and irrigation. By leaving out of consideration the dates followed by the expression (I), which indicates moisture received by irrigation, the amount of water received by the nonirrigated plats can be determined.

1902.	Inches.		1902.	Inches.	
April 29	0.21		July 3 (I)	0.50	
30	.11		5 (I)	.25	
			9	.45	
Total		0.32	14 (I)	.60	
May 3	0.36		16 (I)	[a].45	
	0.16		18	1.31	
	.06		19	Trace.	
	.98		20	.19	
	1.18		21	.22	
	.65		24	.16	
	1.93		30	.75	
	.35		31	.70	
Total		5.67	Total		5.58
June 2 (I)	0.50		Aug. 4	0.25	
5 (I)	.50		6	.94	
7	.57		10	1.02	
11	.15		23	.20	
12 (I)	.50		26	.38	
16	.93		27	.04	
19 (I)	.50				
19	.21		Total		2.83
21	1.22		Sept. 3	1.03	
25	.05		9	1.65	
26	1.60				
30	.37		Total		2.68
Total		7.10	General total		24.18

[a] Applied to plats Nos. 3 and 4 only.

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The analytical and field data, determined for the different plats grown under varying conditions, are shown in the following table:

Agricultural and analytical data on beets grown on the Potomac flats, District of Columbia, showing averages for different dates of planting.

UNIRRIGATED.

Plat No.	Date planted.	Average weight after topping.	Estimated yield per acre.	Sugar in juice.	Sugar in beet.	Purity coefficient.
	1902.	*Ounces.*	*Tons.*	*Per cent.*	*Per cent.*	
1	Apr. 18	18.6	27.9	9.1	8.3	72.3
2	[a]May 2	22.9	26.1	9.2	8.4	72.4
3	May 16	10.6	19.6	9.3	8.5	72.4
4	May 30	9.9	14.4	9.3	8.6	72.1
Average		15.5	22	9.2	8.5	72.3

IRRIGATED.

1	Apr. 18	23.5	18.3	7.7	7.1	67.9
2	May 2	25.4	15.8	8.0	7.4	69.5
3	May 16	12.5	10.8	8.7	8.0	71
4	May 30	12.9	10.8	8.9	8.1	70.5
Average		18.6	13.9	8.3	7.7	69.7

[a] The data for May 2, unirrigated, are platted.

The climatic conditions under which this crop was grown are shown by the following data:

Meteorological data for Washington, D. C.

Month.	Mean temperature.	Precipitation.	Sunshine.			Clear days.	Cloudy days.
			Actual.	Possible.	Per cent.		
1902.	° *F.*	*Inches.*	*Hours.*	*Hours.*			
May	65.4	3.35	290.0	443.8	65	13	4
June	71.8	3.70	306.3	445.9	69	14	5
July	77	2.54	304.6	453	67	11	3
Average and total	71.4	9.59			67	38	12
August	72.6	1.85	321	423.2	76	11	4
September	66.8	5.30	218.4	373.4	58	13	3
October	57.6	6.76	229.1	346	66	18	6
Average and total	65.7	13.91			67	42	13
General average and sum total	68.6	23.50			67	80	25

The rather contradictory data relative to the yields of the unirrigated and irrigated plats call for a word of explanation. The irrigated plats were located at the west end of the field, the rows of beets running east and west. Unfortunately the stand of beets upon this end was not so good as on the central and western portions of the area planted with beets. There were some places in the rows where beets failed to grow, and thus in thinning fewer beets were left in a given length of row on the irrigated than on the unirrigated portion. A single illustration taken at random will illustrate this. On September 16,

50 feet harvested from each of the four plats planted on April 18, May 2, May 16, and May 30 gave the following number of beets respectively: 59, 49, 60, and 54—total, 222. On the same day 50 feet in length from each of the four rows of irrigated beets yielded the following number of beets: 26, 26, 33, and 23—a total of 108, or less than one-half as many as were yielded by the unirrigated plats. This is of course an extreme case, but the same general proportions as to the number of beets harvested on the two plats obtained throughout the season. This condition explains the apparent contradiction in the yields of the two plats since the unirrigated portions, although the beets weighed less, yielded a larger tonnage than the irrigated plats.

By reason of the larger size of the beets on the irrigated area it is not surprising that they were inferior both in sugar content and in purity to those taken from the unirrigated areas. It does not appear that the practice of irrigation had any effect upon the crop. In fact, it was a most unfavorable season to show any good effect of irrigation, since the rainfall, with the one exception of the month of August, was entirely sufficient in quantity and was advantageously distributed. The excess of rainfall in September and October of course had a tendency to continue the growth and retard the period of maturity. Nevertheless, the beets produced were decidedly superior to those of preceding years. This is probably explained by the fact that the mean temperature of the six growing months in 1900 was 71.7°; in 1901, 69°; and in 1902, 68.6°—a steady though slight decrease.

THE INDIANA STATION.

Unfortunately there are no data to be presented for the Indiana station as the crop was a complete failure. Director Huston comments on this fact under date of January 16, 1903, as follows:

> The seed which was received from you was planted upon ground carefully prepared and germinated satisfactorily. On May 20 the beets were up and showing a good stand. On June 10 there were practically no live beets in the field, and Mr. Jones at once had a portion of the field replanted with the reserved seed. This planting also germinated reasonably well, but the enormous rainfall in June destroyed the young beets, so that there was practically nothing left upon the field. We later put soy beans on the field and they failed to grow. I am rather at a loss to understand what was the cause of these failures, as the field had been under two different crops since beets had been raised upon it. I am under the impression that the first planting was injured by the first cultivation, but as the man who attended to it is not here I am unable to be sure that this was the real cause. Last year a crop of soy beans was plowed under on this land and I thought it was in fine condition and had arranged to irrigate a portion of the field and had all the pipes in place for this purpose. Since the failure of the crops on this piece of ground this spring it has been kept in fallow, and I will have it thoroughly prepared this fall and think it ought to be in first-class condition for the beet work next year.

The meteorological data for this season at Lafayette and at Indianapolis, 59 miles to the southeast, are given in the following tables:

Meteorological data for Lafayette, Ind.

Month.	Mean temperature.	Precipitation.	Sunshine.			Clear days.	Cloudy days.
			Actual.	Possible.	Per cent.		
1902.	° F.	Inches.	Hours.	Hours.			
May	65.3	3.64	.....	.....	.....	7	16
June	68.4	11.37	.....	.....	.....	5	15
July	74.8	6.56	.....	.....	.....	11	8
Average and total	69.5	21.57	.....	.....	.....	23	39
August	70.1	1.40	.....	.....	.....	12	13
September	63.3	3.72	.....	.....	.....	10	15
October	56.1	3.27	.....	.....	.....	10	7
Average and total	63.2	8.39	.....	.....	.....	32	35
General average and sum total	66.4	29.96	.....	.....	.....	55	74

Meteorological data for Indianapolis, Ind.

Month.	Mean temperature.	Precipitation.	Sunshine.			Clear days.	Cloudy days.
			Actual.	Possible.	Per cent.		
1902.	° F.	Inches.	Hours.	Hours.			
May	66.0	3.66	300.8	446.7	67.0	4	3
June	69.5	7.52	282.6	449.0	63.0	9	8
July	75.8	3.67	330.9	455.2	73.0	10	3
Average and total	70.4	14.85	.....	.....	67.7	23	14
August	71.6	2.09	262.2	425.2	62.0	10	3
September	64.4	5.33	190.3	373.6	51.0	8	9
October	57.4	2.36	214.1	344.9	62.0	9	5
Average and total	64.5	9.78	.....	.....	58.3	27	17
General average and sum total	67.5	24.63	.....	.....	63.0	50	31

THE KENTUCKY STATION.

The same plat that had been used for the beet experiments in 1900 and 1901 was again assigned for that work in 1902. The land was plowed on April 16, replowed and subsoiled 20 inches deep on April 22. The soil was put in perfect tilth with a smoothing harrow and roller. The seed were planted on the same day about 1 inch deep in rows 18 inches apart, a hand drill being used. The plants were up on April 30, and were cultivated as follows: May 9, hoed; May 14, hoed and plowed; May 21, thinned to 6 inches, hoed and plowed; May 28, thinned to 9 inches and cultivated. At the latter date there was almost a perfect stand, and plants were transplanted to fill the few vacancies that occurred. Throughout the growing season the beets were cultivated once every two weeks.

The early growth of the crop was very vigorous, and the season

until September 1, was favorable. During September and October the beets grew very little, but a considerable growth took place in November.

The analytical data on the samples taken as determined both at Washington and at Lexington are given in the following tables:

Agricultural and analytical data on beets grown at Lexington, Ky.

Date received.	Average weight after topping.	Estimated yield per acre.	Sugar in juice.	Sugar in beet.	Purity coefficient.
1902.	*Ounces.*	*Tons.*	*Per cent.*	*Per cent.*	
September 18	8.0	10.0	9.3	8.6	74.6
October 9	8.6	9.0	7.4	6.8	68.5
October 21	8.0	8.0	7.5	6.9	70.7
October 25	7.2	8.4	7.6	7.0	69.7
Average	8.0	8.9	8.0	7.3	70.9

Sugar beets grown and analyzed at Lexington, Ky.

Date of sampling.	Number of beets taken.	Average weight after topping.	Sugar in the juice.	Sugar in the beet.[a]	Purity coefficient.
1902.		*Ounces.*	*Per cent.*	*Per cent.*	
June 25	7	4.7	8.15	7.50	65.7
August 6	12	12.4	9.53	8.77	78.8
August 19	9	13.7	9.30	8.56	72.3
October 4	4	9.2	7.15	6.58	66.0
October 13	5	8.8	4.75	4.37	57.2
October 21	6	10.0	6.92	6.37	66.1
December 4	6	17.1	8.77	8.07	67.0
December 8	5	14.6	8.38	7.71	67.6
Average		11.3	7.87	7.24	67.0

[a] Calculated at Washington, D. C.

The meteorological conditions existing during the growing season of 1902 at Lexington are shown in the following table:

Meteorological data for Lexington, Ky.

Month.	Mean temperature.	Precipitation.	Sunshine.			Clear days.	Cloudy days.
			Actual.	Possible.	Per cent.		
1902.	° *F.*	*Inches.*	*Hours.*	*Hours.*			
May	68.2	2.43	364.5	441.7	83.0	18	0
June	71.2	5.19	359.3	443.1	81.0	13	4
July	76.8	2.33	361.4	450.1	80.0	14	0
Average and total	72.1	9.95	.....	.....	81.1	45	4
August	73.8	1.89	330.4	422.1	78.0	13	2
September	67.0	2.60	245.1	373.0	66.0	10	7
October	59.0	2.11	241.2	347.3	69.0	15	9
Average and total	66.6	6.60	.....	.....	71.0	38	18
General average and sum total	69.3	16.55	.....	.....	76.1	83	22

The following table, compiled at the Kentucky station, shows the averages in temperature and precipitation for fifteen years prior to 1903, and also the accumulated deficiency of precipitation from January 1, 1902:

Averages for fifteen years, and accumulated rainfall deficiency.

Meteorological data.	May.	June.	July.	Aug.	Sept.	Oct.
Temperature.....degrees F..	64	74	76	74	69	57
Precipitation.....inches..	3.71	4.31	4.06	3.95	2.59	2.11
Accumulated rainfall deficiency from Jan. 1, 1902–Jan. 1, 1903.[a].....inches..	7.36	6.39	8.12	10.18	10.17	10.17

[a] The accumulated deficiency of precipitation for the preceding year, 1901, was 13.28 inches.

Under date of February 11, 1903, Mr. A. M. Peter, chemist of the station, forwarded some additional data obtained on beets from the experimental plat which were harvested in the second week of November and stored in a cellar until January 31, 1903, when they were sampled and the following analyses made:

Data determined on beets stored for two months at Lexington, Ky.

Station number.	Number of beets.	Weight of beet.		Sugar in juice.	Purity.
		Topped.	Trimmed.		
		Ounces.	*Ounces.*	*Per cent.*	
10892	1	16.2	13.2	7.4	72.6
10893	1	15.7	12.0	7.2	59.5
10894	1	15.0	12.5	9.95	71.8
10895	1	16.8	11.8	9.1	72.2
10896	1	13.0	10.5	8.1	65.3
10897	2	10.1	7.9	9.55	71.8
Average		14.5	11.3	8.6	68.9

The results of the experiment at the Lexington station are particularly interesting in that they have again robbed the Washington station of its original position at the foot of the ladder in the production of beets of a low sugar content. The precipitation at Lexington, while below the average, appears to have been sufficient for the needs of the crop. The month of August, however, as at Washington, was somewhat dry. The average temperature for the six growing months was 69.3° or 0.7° higher than at Washington.

THE MICHIGAN STATION.

Under date of May 16, 1902, Director Smith reported that the beets were up and large enough to be cultivated within a week. The season was wet and cold, frosty nights occurring especially during May. The crop harvested was of very high quality, however, as is shown by the following table:

Agricultural and analytical data on beets grown at Agricultural College, Mich.

Date received.	Average weight after topping.	Estimated yield per acre.	Sugar in juice.	Sugar in beet.	Purity coefficient.
1902.	*Ounces.*	*Tons.*	*Per cent.*	*Per cent.*	
September 20	10.9	.....	15.1	13.9	82.1
September 27	10.9	.....	15.0	13.8	86.7
October 7	10.2	12.8	14.4	13.2	86.2
October 14	10.2	12.0	14.4	13.2	86.7
October 21	11.5	14.5	14.8	13.6	87.6
October 28	12.5	.....	15.2	13.9	89.4
November 4	8.3	10.5	15.0	13.8	89.3
Average	10.6	12.5	14.8	13.5	86.9

The meteorological data for Agricultural College and for Detroit, 76 miles to the southeast of the college station, are given in the following tables, the sunshine record not being available for any point nearer to Agricultural College than Detroit:

Meteorological data for Agricultural College, Mich.

Month.	Mean temperature.	Precipitation.	Sunshine.			Clear days.	Cloudy days.
			Actual.	Possible.	Per cent.		
1902.	°*F.*	*Inches.*	*Hours.*	*Hours.*			
May	58.4	4.92	.....	.....	.....	6	11
June	61.8	7.28	.....	.....	.....	9	19
July	70.6	7.13	.....	.....	.....	.....	.....
Average and total	63.6	19.33	.....	.....	.....	15	30
August	64.2	.68	.....	.....	.....	11	7
September	58.7	5.88	.....	.....	.....	11	17
October	49.6	1.53	.....	.....	.....	18	13
Average and total	57.5	8.09	.....	.....	.....	40	37
General average and sum total	60.5	27.42	.....	.....	.....	55	67

Meteorological data for Detroit, Mich.

Month.	Mean temperature.	Precipitation.	Sunshine.			Clear days.	Cloudy days.
			Actual.	Possible.	Per cent.		
1902.	°*F.*	*Inches.*	*Hours.*	*Hours.*			
May	58.4	3.52	298.7	451.9	66	12	6
June	63.9	6.97	235.6	456.2	52	5	9
July	72.8	7.55	291.9	461.8	63	13	7
Average and total	65.0	18.04	.....	.....	60	30	22
August	68.0	.60	285.8	429.4	67	15	5
September	62.2	6.50	186.4	374.5	50	10	12
October	52.4	1.54	177.5	342.5	52	10	11
Average and total	60.9	8.64	.....	.....	56	35	28
General average and sum total	63.0	26.68	.....	.....	58	65	50

The precipitation for the early growing months of May, June, and July was excessive, especially for the two months last named. Dur-

ing the second period of three months the August precipitation was deficient and the September rainfall was excessive, while October was somewhat dry and favorable to securing the maturity of the plants. It is evident that had two-thirds of the September rain fallen in August there would have been a larger yield of beets and perhaps of a better quality. Both the percentage of sugar in the beet and the purity of the juice, however, are very satisfactory.

THE NEW YORK STATION AT GENEVA.

The following cultural data are reported by the Geneva station:

The seed was sown on May 30, 1902. The ground was plowed and subsoiled in the spring to the depth of 14 to 16 inches. The fertilizer intended for the work was mixed and weighed out, but the fire of May 7 destroyed it and before a new supply could be obtained it was too late, and therefore no fertilizer was used.

On June 4 the seed began to vegetate and growth went on rapidly. A very uniform stand was obtained without reseeding. On June 14 the beets were cultivated by hand, and three subsequent cultivations with a one-horse cultivator were given. Thinning was begun on June 27 and finished on June 30. The beets were thinned to approximately 8 inches in the rows, the rows being 20 inches apart. The beets were practically free from leaf spot and grew with vigor throughout the season. The data on the beets determined at the New York station are as follows, each sample representing 50 beets.

Agricultural and analytical data determined at Geneva, N. Y.

Date harvested.	Average weight.	Yield per acre.	Sugar in juice.	Sugar in beet.	Purity coefficient.
1902.	*Ounces.*	*Tons.*	*Per cent.*	*Per cent.*	
October 14	13.8	.....	17.1	14.9	91.9
November 13	17.5	16.06	17.1	14.3	87.4
Average	15.7	16.06	17.1	14.6	89.7

The data determined at Washington, D. C., on the beets forwarded from Geneva are shown in the following table:

Agricultural and analytical data on beets grown at Geneva, N. Y.

Date received.	Average weight after topping.	Estimated yield per acre.	Sugar in juice.	Sugar in beet.	Purity.
1902.	*Ounces.*	*Tons.*	*Per cent.*	*Per cent.*	
September 22	10.6	.....	15.1	13.9	83.9
September 30	13.1	.....	15.7	14.4	84.4
October 9	14.4	.....	14.1	12.9	83.9
October 14	17.4	.....	14.1	12.9	83.4
October 21	14.7	.....	15.1	13.9	86.3
October 29	14.7	.....	15.3	14.1	85.5
November 4	12.5	.....	15.9	14.6	85.0
November 11	17.6	.....	15.6	14.4	84.3
November 18	13.7	.....	15.3	14.1	84.1
Average	14.3	[a]16.1	15.1	13.9	84.5

[a] Estimate made at Geneva.

Unfortunately only very scanty meteorological records are procurable for this locality, the temperature and precipitation record kept at the voluntary station at Lyons, 13 miles north of Geneva, furnishing the only data available except rainfall reported from Geneva in the following paragraph.

Meteorological data for Lyons, N. Y.

Month.	Mean temperature.	Precipitation.
1902.	°F.	*Inches.*
May	58.8	3.03
June	64.0	3.39
July	72.4	6.77
Average and total	65.1	13.19
August	67.8	2.22
September	64.4	2.57
October	51.0	2.79
Average and total	61.1	7.58
General average and sum total	63.1	20.77

The following comments on the season are made in the station report on the experiment:

The season was an unusual one in some respects. Periods of excessive moisture were followed by drought, making it difficult to give the crop frequent cultivation. The rainfall as observed at Geneva for the growing season was as follows:

	Inches.		Inches.
June	4.33	October	2.32
July	5.25		
August	2.41	Total	17.19
September	2.88		

In June the longest period without rain was three days. From July 9 to 15 was dry. In August the longest period with no rain was five days, from August 12 to 17. In September there was but 0.75 inch from the 1st to the 22d. The coldest October and the warmest November were experienced that have been known in this latitude for twenty years.

The analytical data determined at the Geneva station and those obtained at Washington vary somewhat, the Geneva figures for purity and sugar in the beet being higher. Only two samples, however, were examined at Geneva, and those were of the perfectly matured beets, the samples having been taken on October 14 and November 13, while the samples received at Washington covered a range of harvesting from the last of September to the middle of November. The difference in the percentages of sugar in the beets as obtained at the two stations is only 0.7 per cent, while the difference in the purity coefficients is 5.2 per cent. Following the usual rule, the data obtained in this laboratory have been platted in preference to those of the collaborating station. This is not done because of any assumed greater degree of accuracy, but because the analyses made here are all per-

formed under standard and uniform conditions. In point of fact there may possibly be some slight deterioration in the samples sent to Washington, especially those coming a long distance. This deterioration can never be very great, however, if the directions for packing and shipping are followed carefully.

THE NEW YORK STATION AT ITHACA.

The following report on the beet work as conducted at the Ithaca station was made by Mr. J. L. Stone, assistant in agriculture, under date of December 4, 1902:

The sugar-beet seed No. 8238 of the Department of Agriculture was planted May 13, 1902, at the extreme southwest corner of the permanent series of plats. * * * The land was plowed early and harrowed at intervals till the time of planting. Seed was sown with a hand drill, the distance between the rows being 22 inches. The dates of cultivation seem not to have been recorded, but the crop was well cared for, no weeds being observed when the plats came into the writer's care in September. The plants were thinned to a stand on June 19. When harvesting began on September 18 the beets were immature, and the soil had been very wet most of the time since early June. The last days of September were bright and sunny. October was nearly normal as regards precipitation, but the soil was still quite wet from earlier rains. November, up to the 25th of the month, was unusually warm, with little rainfall. Second growth had taken place to a considerable extent. * * * The following are the dates of harvesting and data relating to the same:

Agricultural data determined at Ithaca.

Date of harvest.	Number of beets in 50 feet.	Total weight with crowns.	Weight of 25 beets.	Dockage.	Estimated yield per acre (trimmed).
1902.		*Pounds.*	*Pounds.*	*Per cent.*	*Tons.*
September 18	67	68.0	25.0	10.4	14.47
September 25	66	70.0	26.0	12.5	14.55
October 2	62	82.0	35.0	8.5	17.83
October 9	64	82.0	33.0	8.5	18.24
October 17	71	87.0	34.5	10.0	18.61
October 25	60	91.5	37.0	9.3	19.72
November 1	63	85.5	33.5	10.5	18.18
November 10	58	79.5	35.0	9.0	17.19
November 17	63	94.5	37.0	8.7	20.75
November 25	60	102.5	45.0	14.0	20.94
Average	63	84.3	34.1	10.1	18.05

Evidently the per cent of dockage was materially increased at the last date owing to the second growth and the consequent increase in the weight of the crown. However, it is evident that at different dates of harvest the manner of trimming the beets was not quite uniform or the per cent of dockage would not vary so irregularly.

The following tables show the data determined at Washington on the beets shipped from the Ithaca station, and also the climatic conditions under which they were grown:

Agricultural and analytical data on beets grown at Ithaca, N. Y.

Date received.	Average weight after topping.	Estimated yield per acre.	Sugar in juice.	Sugar in beet.	Purity coefficient.
1902.	*Ounces.*	*Tons.*	*Per cent.*	*Per cent.*	
September 22	13.1	10.9	13.1	12.1	81.9
September 30	13.8	10.9	12.9	11.9	82.7
October 7	17.3	14.1	11.7	10.8	79.1
October 14	16.6	20.1	12.1	13.9	79.6
October 21	17.9	20.5	13.2	11.1	81.5
October 29	19.8	21.4	14.0	12.9	83.8
November 7	16.6	20.0	14.2	13.1	85.0
November 14	17.6	19.2	14.3	13.1	85.6
November 22	16.0	19.9	14.4	13.2	82.7
November 29	21.6	23.0	13.6	12.6	76.8
Average	17.03	18.0	13.3	12.5	81.87

Meteorological data for Ithaca, N. Y.

Month.	Mean temperature.	Precipitation.	Clear days.	Cloudy days.
1902.	° *F.*	*Inches.*		
May	54.5	2.05	8	10
June	62.2	5.39	4	5
July	69.8	6.69	6	10
Average and total	62.2	14.13	18	25
August	65.6	3.13	9	6
September	61.1	2.70	11	8
October	49.2	3.36	3	15
Average and total	58.6	9.19	23	29
General average and sum total	60.4	23.32	41	54

The agricultural data from the Ithaca station are very full and satisfactory, but no chemical analyses of the samples were made at the station. The results of our analyses show, as in previous years, that the beets grown at the Ithaca station are slightly inferior to those produced at the Geneva station, although the difference of location of the two stations is not very great. A comparison of the climatic conditions existing at the two stations is not directly possible, because practically no data are given for Geneva itself. In comparing the meteorological data given for Lyons, 13 miles from Geneva, with the Ithaca report, we find that the temperature at Ithaca is lower than at Lyons, which would be contrary to the general rule that the lower temperature favors the production of a richer beet.

THE VIRGINIA STATION.

Details in regard to the sugar-beet experiment at the Blacksburg station were reported by Mr. Alwood, under date of September 13, 1902, as follows:

The land chosen for the plat this year is a fairly strong clay loam which had been farmed in corn the two previous years and heavily cropped, using some phosphate;

how much I can not say positively. This land came to the garden department last fall. We covered it very heavily with manure and plowed it in the late fall, and it was left rough all winter. This spring before planting we harrowed the land severa times and then on April 30 replowed and subsoiled it down to 18 inches. The land was put in fine tilth before planting. There was so much manure in the soil that the soil samples were not taken at that time. * * * On May 1 the plat was sown with seed No. 8238, using a garden drill, and placing the rows about 18 inches apart. The seed was sown thickly in the row. The season turned exceedingly dry from May 1 and has so continued up to this date, yet the fine condition of the land has enabled us to grow a very fair crop.

Vegetation occurred in one week, and for several weeks the land was cultivated with a hand tool, giving a shallow cultivation once each week, and the beets were thinned as directed in the instructions. By June 30 the growth of tops was so luxuriant that the ground was practically hidden from view. On September 1 the outer leaves began to fall down and rest on the surface of the soil. On this date 50 feet of row was sampled, with the following results:

Number of beets in 50 feet of row		72
Weight of beets, leaves removed only	pounds	76
Weight of 25 beets not topped	do	31⅝

Under date of September 19 the following additional report was made:

I sent you yesterday the second sample of beets, and the data concerning the same are as follows:

Fifty feet of row in this case dug only 57 beets. It happened that this section of row had a number of vacant spots. I have already mentioned that the drought was very severe here at the time of planting. This number of beets weighed, after taking off the leaves, 60 pounds. The weight of the 25 beets sent to you was 27¾ pounds.

There was a very heavy frost here last Sunday morning, and a somewhat slighter frost occurred Monday morning [September 14 and 15]. The result is that the tops of the beets are now much fallen over, though they are not blackened nor killed, but I think the crop is practically at full maturity, or at least will be next week.

The data obtained on the samples of these beets shipped to Washington from the Blacksburg station are given in the following table:

Agricultural and analytical data on beets grown at Blacksburg, Va.

Date received.	Average weight after topping.	Estimated yield per acre.	Sugar in juice.	Sugar in beet.	Purity coefficient.
1902.	*Ounces.*	*Tons.*	*Per cent.*	*Per cent.*	
September 16	16.0	.....	12.0	11.0	71.4
September 20	13.8	.....	13.3	12.2	78.7
September 27	16.6	.....	12.8	11.8	73.6
October 9	15.0	.....	12.9	11.9	73.7
Total	15.4	[a] 16.7	12.8	11.7	74.4

[a] Approximate estimate made on data given in reports of September 1 and 19.

The meteorological data reported for Blacksburg are as follows:

Meteorological data for Blacksburg, Va.

Month.	Mean temperature.	Precipitation.	Clear days.	Cloudy days.
1902.	° *F.*	*Inches.*		
May	63.9	1.85	20	2
June	68.4	2.90	10	8
July	72.5	4.09	10	6
Average and total	68.3	8.84	40	16
August	71.3	1.06	9	8
September	63.2	2.22	13	9
October	55.1	3.06	12	13
Average and total	63.2	6.34	34	30
General average and sum total	65.8	15.18	74	46

Although Blacksburg is considerably south of both Washington and Lexington, the mean temperature for the six months of the growing season is 2.8° less than at Washington and 3.5° lower than at Lexington. The low latitude of course produces a shorter length of day for the growing season, so that the hours of sunlight at Blacksburg are fewer than at Washington or Lexington. Nevertheless the low temperature occasioned by the great altitude is reasonably favorable to the production of beets with a high content of sugar. The purity of the juices, however, is far below the standard for beets of a richness of almost 12 per cent. The yield per acre is fairly satisfactory.

THE WISCONSIN STATION.

A detailed and very interesting report on the sugar-beet experiment, as conducted at Madison, was made by Mr. F. W. Woll, station chemist, and Mr. R. A. Moore, agriculturist. The report is given practically in full, as follows:

The land on the university farm devoted to sugar beets during the past season was about two-fifths of an acre in area. The soil is a clay loam with a heavy clay subsoil and has a decided tendency to bake after rains, a thick, solid crust being then formed on the surface. During the frequent heavy rains in June and July the soil became quite hard and compact, and the effect of this was seen in the shape of the beets harvested, many of them being forked and abnormally thick and short.

The field, which lies in the western portion of the experimental plat grounds, was divided into 7 plats of one-twentieth of an acre each. Cereal and rape crops were grown on plats Nos. 1 to 5 during the two previous seasons, while the two plats farthest north (Nos. 6 and 7) were in clover during these years. The field was in a high state of fertility. A medium application of barnyard manure was put on plats Nos. 1 to 5 in the fall of 1901 previous to plowing, while plats Nos. 6 and 7 were plowed about 6 inches deep in the spring of 1902. In addition to barnyard manure three of the plats received the following artificial fertilizers: Plat No. 4, 50 pounds of Armour's Sugar-Beet Grower, 29 pounds of nitrate of soda, and 20 pounds of sulphate of potash. The commercial fertilizers were harrowed in directly before plant-

ing, except in case of the nitrate, of which one-half was applied at planting time and the remainder when the beets were thinned.

The beet field was disked and harrowed on April 15, and again on April 24, when the seed bed was carefully prepared and the seed planted in rows 18 inches apart, at the rate of 20 pounds to the acre. The field was harrowed lightly after the seed was put in. It was cultivated with a hand cultivator on May 8, 19, 22, and June 3. The beets were hand-hoed on May 22 and June 20, and thinned on May 26, so that the plants stood approximately 9 inches apart in the row. The field did not receive any further treatment after June 20 until harvesting time, except that all weeds were pulled by hand on July 21. The stand of the beets was perfect and the field presented a fine appearance, the beets looking thrifty and strong throughout the growing period.

Owing to the abundance of moisture during the summer months and the cool weather during August and September the beets matured later than is usually the case in this locality. Samples of the beets grown on plat No. 4 were taken every week from September 14 to October 11, as requested by the Bureau of Chemistry, United States Department of Agriculture. The beets in 50 feet of row were dug and weighed before and after being washed, 3 beets of average size being taken in each case for a sample. The results of the weighings and analyses made on the different dates of sampling, as obtained at this station, are shown in the following table:

Agricultural and analytical data determined at Madison, Wis.

Date of sampling.	Average weight.		Estimated yield per acre (washed).	Sugar in juice.	Sugar in beet.	Purity coefficient.
	Beets as dug; topped at crown.	Washed; topped below leaf buds.				
1902.	*Pounds.*	*Pounds.*	*Tons.*	*Per cent.*	*Per cent.*	
September 14	1.5	1.03	30.0	14.4	13.3	78.6
September 20	1.6	1.17	27.3	14.3	13.2	79.3
September 27	1.8	1.58	34.8	14.0	12.9	83.3
October 4	1.8	1.58	33.1	15.7	14.4	81.0
October 11	.....	1.26	29.7	13.8	12.7	77.4
Average	1.7	1.32	31.0	14.4	13.3	79.9

Single analyses do not always give a correct indication of the maturity of the beets at the time of sampling, and the results, therefore, should not be interpreted too strictly. But slight improvement occurred in the sugar content or purity of the beets after the first sampling, as far as could be observed.

The following table shows the data obtained at the Bureau of Chemistry for the samples shipped from the Madison station on the dates of sampling given in the preceding table:

Agricultural and analytical data on beets grown at Madison, Wis., as determined at Washington, D. C.

Date received.	Average weight after topping.	Estimated yield per acre.	Sugar in juice.	Sugar in beet.	Purity coefficient.
1902.	*Ounces.*	*Tons.*	*Per cent.*	*Per cent.*	
September 17	17.8	.....	13.6	12.5	82.4
September 30	20.2	27.3	14.0	12.9	80.5
October 1	16.3	35.0	14.5	13.3	84.8
October 9	25 9	33.0	13.0	12.0	79.3
October 21	40.6	.....	13.9	12.8	83.2
Average	24.2	31.8	13.8	12.7	82.0

The report of the Wisconsin station continues as follows:

Usually beets grown in this locality are ready for harvesting during the first half of the month of September. The beets this year, however, were not harvested until October 11. Those grown on the different plats were of course kept separate, while those grown in the spaces between the plats were thrown together and sampled separately, the data for these beets being given under plat No. 8 in the following table:

Agricultural and analytical data determined at Madison at the time of harvest.

Plat No.	Average weight.	Yield per plat.[a]	Yield per acre.	Sugar per acre.	Sugar in juice.	Sugar in beet.	Purity coefficient.
	Pounds.	*Pounds.*	*Tons.*	*Pounds.*	*Per cent.*	*Per cent.*	
1	1.34	3,196	32.0	8,871	14.22	13.08	85.2
2	1.42	3,042	30.4	8,637	15.49	14.25	82.6
3	1.27	3,115	31.2	8,811	15.37	14.14	87.3
4	1.26	2,974	29.7	7,489	13.77	12.67	81.0
5	1.44	3,054	30.5	8,333	14.85	13.66	83.1
6	1.42	2,814	28.1	7,789	15.06	13.86	85.1
7[b]	1.46	2,755	27.6	7,529	14.83	13.64	88.4
8	1.12	2,533	29.9	8,647	15.72	14.46	85.0
Total and average	1.34	23,483	29.9	8,213	14.91	13.72	84.5

[a] Each plat about one-twentieth of an acre.
[b] Beets taken from spaces between plats.

The most striking feature of the results presented in the preceding table is the large tonnage. More than 11 tons of washed beets were harvested from an area of only about two-fifths of an acre, which represents a yield of nearly 30 tons per acre. This is an extraordinary tonnage, which has never been equaled in previous trials with sugar beets at this station. The following summary shows the average yields of sugar beets obtained at the university farm during the past twelve years:

Average annual yield of sugar-beet crop for twelve years.

Season.	Yield per acre.	Sugar per acre.	Season.	Yield per acre.	Sugar per acre.
	Tons.	*Pounds.*		*Tons.*	*Pounds.*
1890	19.80	5,913	1900	16.99	3,862
1891	7.34	2,267	1901	10.97	2,623
1892	11.31	3,821	1902	29.94	8,213
1897	9.13	2,503			
1898	18.71	5,312	Average	15.89	4,258
1899	18.83	5,805			

The unusually large tonnage of 1902 is no doubt to be attributed to the following three causes: The abundant supply of moisture during the growing season; the high state of fertility of the soil on which the seed was planted; and the long vegetation period which obtained, the seeds having been planted and the beets thinned nearly one month earlier than had been the practice in previous years. While the beet field was not large there would have been no difficulty in securing a yield of the same proportions for a larger area had there been a sufficient force at the University farm to cultivate it.

The expense of growing an acre of beets under ordinary conditions is generally estimated to be from $25 to $30. Beets of the quality of those grown at the University farm during the past season are paid for at the sugar factory at Menomonee Falls, Wis., at the rate of $4.42 per ton. This would make the product from an acre worth $132.60, a net profit of upward of $100 per acre. The expense of the labor required to keep the field free from weeds was higher this year than in ordinary seasons on account of the difficulty in getting to the field at the right time after the many heavy rainstorms during the early part of the summer. The profit of growing

an acre of beets with a yield like that secured during the past season would at all events be very large. The results of investigations conducted at this station in the past have shown that even if the yield of beets should be only one-half of that obtained this year the beet crop would still be a very profitable one for Wisconsin farmers to engage in if they are within a reasonable distance of a beet factory. Estimating the value of the beets and the cost of growing them as above, there would still be a net profit on a crop of half the size of that of 1902 of about $40 per acre of beets grown. It is believed that there are few crops that can be grown in this State which will pay better during a series of years than sugar beets, provided proper attention is given to the crop. As one sugar factory has been in operation in this State for two seasons, and one or two more will in all probability be erected in time for next season's crop the farmers in many localities in our State will soon have an opportunity to engage in the growing of sugar beets for factory purposes. The practical importance of the subject to the farmers of Wisconsin is therefore evident.

In the following table are given the climatic data available for Madison. Mr. Shaw, in commenting on the season, said that the excessive rains of July, followed by almost continuous cloudy weather, while unfavorable for cereal crops, was very favorable to the growth of green forage and root crops, of which large yields were harvested.

Meteorological data for Madison, Wis.

Month.	Mean temperature.	Precipitation.	Clear days.	Cloudy days.
1902.	°F.	*Inches.*		
May	59.8	5.16	3	17
June	63.2	4.27	3	18
July	71.3	8.98	4	13
Average and total	64.8	18.41	10	48
August	66.8	.78	11	7
September	58.2	4.18	8	13
October	51.4	1.23	9	8
Average and total	58.8	6.19	28	28
General average and total	61.8	24.60	38	76

The agricultural data obtained from the Wisconsin station are particularly satisfactory in their fullness and detail. The yield per acre, as estimated from the harvested areas, is extremely high. The average weight of the beets is particularly satisfactory, and it is only with beets of this average weight that such high yields can be obtained. In the samples harvested on October 21 and sent to this Bureau the average weight of the beets was phenomenally high, and yet there was no decrease either in the percentage of sugar in the beet or in the purity; in fact, this sample, both in respect of the sugar in the beet and purity, was above the average of the other samples. There is a slight discrepancy between the analytical data obtained at Madison and at this Bureau, in that the figures obtained at Washington for the content of sugar and purity are somewhat lower. The high yield may be attributed to a naturally fertile soil, well prepared, judicious fertilization, timely culture, and a favorable amount and distribution of

rainfall. During the first growing period of three months the rainfall was probably excessive, and especially was this true of the month of July. August, as at most of the stations, was a dry month, and September somewhat too wet. October was favorable for ripening and harvesting. The mean temperature was low, thus favoring a high sugar production. The record for this year, upon the whole, must be regarded as extremely satisfactory, and may well be taken as a model for work of this kind.

EXPERIMENTS CONDUCTED IN IRRIGATED SECTIONS.

THE CALIFORNIA STATIONS.

A very complete and interesting report was received from G. W. Shaw, of the California station, in regard to the sugar-beet experiment as conducted at that point. The report is here given practically in full:

The cooperative experiment with sugar beets was conducted under the supervision of the writer at the Pomona substation grounds and on the 10-acre tract at Chino. These localities are but a few miles apart, and their climatic conditions are the same, the only difference in the two localities being in the character of the soil, and in the fact that at Pomona the beets were grown under irrigation and at Chino without irrigation. The soil was prepared by a deep spring plowing, and worked to a fine tilth. The seed was planted on April 2, in drills 20 inches apart, the entire plat being 160 by 75 feet.

Pomona (Irrigated).

The seeds were slow to germinate, and on April 14, the beets on the Pomona tract were irrigated to hasten germination. To secure a uniform stand beets were transplanted to fill vacant spaces in the rows on May 5, and again on May 14, and the plat was thinned from May 6 to 8.

Including the early irrigation mentioned above, the beets received the following-named quantity of water on the dates given:

Irrigation data, Pomona, Cal.

Date of irrigation.	Amount of water remaining on plat.		
1902.	*Gallons.*	*Cubic feet.*	*Acre-inches.*
April 14	12,500	1,671	.....
May 20	5,000	668	.....
June 17	14,000	1,871	.....
July 15	8,750	1,169	.....
July 22	8,575	1,146	.....
July 29	8,575	1,146	.....
August 5	8,575	1,146	.....
Total	65,974	8,817	2.41

The above figures represent the actual amount of water remaining on the plat, as the wastage was estimated as exactly as possible and subtracted from the amount applied. In addition to the 2.41 acre-inches of water received by irrigation, the soil had the benefit of the following natural rainfall during the year:

	Inches.
October, 1901	2.29
November	.67
January, 1902	1.92
February	3.35
March	3.85
April	.25
May	.10
Total by rainfall	12.43
Total by irrigation	2.41
Total water	14.84

Of this total amount, 2.76 inches were applied after planting. It should be stated that the soil is not one retentive of moisture, and except for irrigation would not produce a crop requiring as much moisture as sugar beets, although the season in this locality in other particulars would be considered as favorable for the crop. The analytical and field data on the crop of 1902 are as follows:

Agricultural and analytical data determined at Pomona, Cal.

Date harvested.	Yield per acre.	Sugar in juice.	Sugar in beet.	Purity coefficient.
1902.	*Tons.*	*Per cent.*	*Per cent.*	
September 26		18.7		83.8
October 4		17.8	15.48	85.6
October 11		15.5		91.0
October 18		15.3	14.60	84.5
October 25		15.8	15.00	87.7
November 1		15.1		87.4
November 8		16.8		85.5
Average	5.0	16.4	15.02	86.5

It will be noted that the beets sampled first had the highest percentage of sugar, and it may be that an earlier sampling would have shown even a higher sugar content. During the period of sampling the beets lost about 3 per cent in sugar, but gained that much in purity; hence the actual sugar content remained about the same. There was, however, no decided increase in tonnage. The planting of the beets was decidedly too late for this coast, producing a disastrous effect on the yield, which was but a trifle over 5 tons per acre. The poor quality of the soil also influenced the low yield to a great extent.

The factor showing the relation of sugar in the beet to sugar in the juice, as determined by the hot aqueous method, was 91.6, which my experience leads me to believe to be much nearer the truth for beets in the Western States than the time-honored one of 95 so commonly used and accepted as correct.

CHINO (ALKALI SOIL, NOT IRRIGATED).

The results obtained on the 10-acre alkali tract at Chino are shown in the following table:

Agricultural and analytical data determined at Chino, Cal.

Date harvested.	Estimated yield per acre.	Sugar in juice.	Purity coefficient.
1902.	*Tons.*	*Per cent.*	
September 26	7.40	17.00	87.2
October 4	5.46	17.65	89.6
October 11	13.85	14.70	87.5
October 18	15.71	16.30	89.5
November 1	8.65	13.70	87.7
November 8	9.58	13.10	85.6
December 2	11.71	14.42	88.8
Average	10.84	15.27	88.1

The results on this land are clearly favorable, and show that beets of high quality can be produced upon soil containing at least 5,480 pounds of alkali per acre-foot, and other experiments show that this amount may be exceeded provided the percentage of chlorids and carbonates does not rise too high.

It is noticeable that the beets grown on this tract also fell off materially in sugar content after October 1. This was not due in either case to rainfall nor to irrigation, since from May until November 24 there was no rain, and irrigation was discontinued on August 5 at Pomona. Just why there should be this sudden decrease in sugar is not clear; the fact, however, is quite striking in both cases. The average factor showing the relation between the sugar in the beet and the sugar in the juice for this plat was 93.1.

The meteorological data furnished by the voluntary station near Pomona, considered in connection with those from the Los Angeles station, about 15 miles west of the Pomona and Chino experiment grounds, give a complete record of the climatic conditions for the growing season.

Meteorological data for (near) Pomona, Cal.

Month.	Mean temperature.	Precipitation.	Sunshine.			Clear days.	Cloudy days.
			Actual.	Possible.	Per cent.		
1902.	°F.	*Inches.*	*Hours.*	*Hours.*			
May	64.1	0.10				13	2
June	72.5	.23				11	0
July	74.0	.00				6	0
Average and total	70.2	.33				30	2
August	73.8	.00				8	0
September	72.8	.00				11	0
October	62.6	.26				18	4
Average and total	69.7	.26				37	4
General average and sum total	70.0	.59				67	6

Meteorological data for Los Angeles, Cal.

Month.	Mean temperature.	Precipitation.	Sunshine,			Clear days.	Cloudy days.
			Actual.	Possible.	Per cent.		
1902.	° *F.*	*Inches.*	*Hours.*	*Hours.*			
May	60.7	0.03	318.8	432.6	74.0	8	1
June	66.4	Tr.	295.4	431.5	68.0	10	1
July	68.4	Tr.	268.7	439.7	61.0	9	3
Average and total	65.2	.03	.....	.....	67.7	27	5
August	69.1	Tr.	314.0	415.8	76.0	12	0
September	69.2	Tr.	275.2	371.8	74.0	11	1
October	63.2	.40	236.0	350.9	67.0	11	6
Average and total	67.2	.40	.....	.....	72.3	34	7
General average and sum total	66.2	.43	.....	.....	70.0	61	12

The work inaugurated with irrigation stations marks the beginning of the study of a new consideration as affecting the activity of different factors of the environment upon the composition of the crop. In the reports from the California stations just given we find an illustration of what has been well demonstrated regarding the ability of irrigated lands to produce crops of sugar beets phenomenally rich in sugar. At the Pomona station the yield per acre is not satisfactory, although with such rich beets as were there raised the farmer could secure a satisfactory monetary return for the crop produced. The yield was not quite one-half as large as that produced on the Chino plat which was not irrigated. This is evidently a case in which a judicious intensive fertilization would very largely increase the yield without diminishing to any notable extent the percentage of sugar or the purity of the juice, and would, therefore, be highly profitable.

In regard to the meteorological data the principal points to be considered are that, although the mean temperature for the six growing months is higher than at Washington, there were no periods of intense heat; June, July, August, and September had almost an even temperature. At Los Angeles there was also an even temperature, September being the warmest month. The general average for the six months was 3.8° lower than at Pomona. The rainfall at both stations was so small as to be negligible. The high percentage of sunshine is of course to be expected under such meteorological conditions as obtained at the California stations mentioned. It is evident that continuous sunshine, where the temperature does not run too high, is not injurious in any way to the functional activity of the chlorophyll cells. Where sufficient moisture is supplied by irrigation and a proper quantity of suitable plant foods exists, the other conditions combine to make such regions almost ideal for beet culture.

THE COLORADO STATION.

As several sugar-beet experiments were conducted at the Colorado station in 1902, it has been impossible to separate all mention of the other work from that carried on with seed No. 8238 of this Bureau, especially since all the beet plats received the same treatment and were planted at the same time, each plat being, however, clearly distinguished from the others. The following extracts from the general report made by A. H. Danielson, agronomist of the Colorado station, give the details of the conduct of the experiment at Fort Collins:

The soil this season had been plowed, harrowed, and leveled with a drag until it was in the best possible condition. As a result of the rain and snow storm on April 14 there was plenty of moisture in the soil to insure the germination of the seed. The ground was leveled twice just before drilling in the beet seed, stirring the soil in such a thorough manner as to give the beets an equal chance with the weeds. If anything, the soil was a little too loose and mellow.

One plat of variety No. 8238 was planted on April 17 near the edge of the field where the soil was not in the best possible condition on account of the tramping of the animals in working the soil. However, this condition seemed to affect the three or four outside rows only. To insure an equal comparison between the various stocks of beets this variety was again planted next day near the center of the field. All other varieties were planted on April 18, in rows east and west 20 inches apart and to an average depth of three-fourths to 1½ inches, with a regulation "shoe" beet drill with the press wheels on, set about three-fourths of an inch apart, so that the soil was not compacted immediately over the seed, but only on each side of the row. There was planted just two drill widths of each variety or stock, making eight rows of each.

Seed was planted at the rate of about 22 pounds per acre, the idea being to plant enough seed to make a full stand of beets. The beet seed evidently appreciated the good treatment it had received; for on the ninth day a few were coming up, and on April 28 the young plants were just breaking the crust. On May 2 every row was showing distinctly, with no difference whatever in the rate of germination between the various stocks of seed.

Thinning the beets to a distance of 8 inches apart was begun on May 29, and finished on June 6. At the beginning the young plants had an average of 7 leaves to a plant and at the last the beets had increased to an average of 12 leaves to the plant.

When the beets had attained some size cultivation was begun, the first being given on May 22 with the beet cultivator. As a rule after the beets had become of some size a furrow was made between the rows at the time of cultivating to allow of irrigation later. The water used in irrigating was not measured, but from previous experience a close estimate is believed to be about 0.3 or 0.4 foot over the ground at each period. The water was allowed to flow between the rows until the soil was thoroughly saturated.

The following notes were made in the field at the time:

May 22.—Cultivated with beet cultivator for the first time.

May 24.—The young plants are growing very rapidly, but some roots show an attack of a fungous disease like "damping off." The roots of some of the young plants are dead and shriveled and others partly decayed. It is believed this disease may be due to the fungous disease "rhizotonia," which pervades our soils in this locality.

June 10.—Cultivated and furrowed for irrigation.

June 12.—Irrigating the beets; the water ran in the furrows an average of twelve hours each; some furrows had water as long as forty-eight hours. The beets are doing well and look exceedingly thrifty. A fine stand, none missing. An inspector from a sugar factory said it was the best stand on a small area in the neighborhood.

June 18.—Cultivated.
June 19.—Weeds hoed out and ground cleaned by hand.
June 27.—The beets are exceedingly thrifty, almost covering the ground; hardly a weed in evidence.
July 24.—Cultivated and furrowed for irrigation at the same time. The soil is very moist from recent rains.
July 26, 27, 28.—Irrigated thoroughly with small head of water. Water is very scarce just now. This is the last irrigation the beets can receive.
July 31.—Weeded by hand.

On September 12 an early frost damaged the leaves to such an extent that the selection of beets for mother beets, from the character of the leaves, was suspended for a time. The leaves began to grow again in a few days, and in a couple of weeks an entire new crop of leaves was out, when the selection was continued. The recovery of growth was helped greatly by the downpour of rain on September 20–21, amounting to nearly 6 inches. It was feared at first that this heavy rain would retard the ripening of the beets or lessen the sugar content considerably. That this did not take place to any great extent is shown by the analysis of samples of these beets taken from one of the plats during the harvesting season and analyzed at the Bureau of Chemistry. The results obtained on all the samples sent to Washington for examination are shown in the following table:

Agricultural and analytical data on beets grown at Fort Collins, Colo.

Date received.	Average weight after topping.	Estimated yield per acre.	Sugar in juice.	Sugar in beet.	Purity.
1902.	*Ounces.*	*Tons.*	*Per cent.*	*Per cent.*	
September 24	18.2	20.2	14.0	12.9	80.5
October 7	18.3	26.0	13.1	12.1	78.3
October 9	19.8	.....	11.4	10.5	74.0
October 21	22.4	.....	10.6	9.8	66.6
October 28	16.5	20.2	14.4	13.2	81.4
November 1	21.4	.....	15.5	14.3	83.8
November 11	21.4	31.7	15.1	13.9	80.4
November 14	19.5	24.3	16.0	14.7	87.0
November 22	15.2	28.1	15.6	14.4	84.3
November 29	19.5	28.5	14.9	13.7	78.0
December 6	20.9	26.7	14.8	13.6	79.1
December 13	23.3	20.7	14.1	13.0	79.7
Average	19.7	24.0	14.1	13.0	79.4

The general yield of sugar beets in northern Colorado this season was not as satisfactory as it might have been, the average yield being nearly 9 tons per acre. A close study and measurement of this field showed that the stand of beets could have been at least 10 per cent better, there being one beet out of every ten missing, or an open space in which a beet should have been growing. This was general over the field and not confined to any one variety.

The meteorological conditions under which these beets were grown are given in detail below, Cheyenne, Wyo., 40 miles northeast of Fort Collins, being the nearest station at which the sunshine data were available. In general the weather was too dry for beets. At the beginning of the ripening season, however, the event most worthy of note was the heavy September rain and the general wet weather prevailing for some weeks thereafter.

Meteorological data for Fort Collins, Colo.

Month.	Mean temperature.	Precipitation.	Sunshine.			Clear days.	Cloudy days.
			Actual.	Possible.	Per cent.		
1902.	°F.	Inches.	Hours.	Hours.			
May	56.1	2.13					
June	63.6	2.43					
July	66.0	1.31					
Average and total	61.9	5.87					
August	68.7	.67					
September	56.8	7.12					
October	48.8	1.15				15	8
Average and total	58.1	8.94				49	17
General average and sum total	60.0	14.81				94	32

Meteorological data for Cheyenne, Wyo.

Month.	Mean temperature.	Precipitation.	Sunshine.			Clear days.	Cloudy days.
			Actual.	Possible.	Per cent.		
1902.	°F.	Inches.	Hours.	Hours.			
May	52.8	2.51	245.9	449.1	55.0	7	12
June	61.0	1.55	266.3	451.9	59.0	7	12
July	63.8	1.49	295.2	458.6	64.0	10	7
Average and total	59.2	5.55			59.3	24	31
August	67.0	0.53	261.0	427.4	61.0	9	7
September	54.0	3.52	273.9	374.0	73.0	14	6
October	47.8	0.52	218.2	343.9	63.0	11	10
Average and total	56.3	4.57			65.7	34	23
General average and sum total	57.8	10.12			62.5	58	54

In the data from Colorado we have a remarkable contribution to the study of the effect of environment upon composition. The total rainfall for the six growing months was 14.81 inches, only 2 or 3 inches below the average precipitation for the nonirrigated stations. The distribution, however, was somewhat unfavorable, as nearly one-half the total quantity fell during the month of September. During the dry months the deficiency in rainfall was corrected by irrigation. The temperatures were low compared with those of the other irrigated areas, the average for the six months being only 60°. There was a large percentage of clear days, and it is evident that the beets received an abundance of direct sunshine.

The yield per acre was very heavy, being nearly five times that obtained at the Pomona, Cal., station, and two and a half times that of the nonirrigated station at Chino. The percentage of sugar in the beet is reasonably satisfactory, but the purity is somewhat too low. It is stated in the report of Mr. Danielson that in richness the beets in northern Colorado were not up to the standard of previous years. With the large yields obtained, however, the yield of sugar must be regarded as highly satisfactory.

THE UTAH STATION.

The following cultural and analytical data have been reported by Director Widtsoe of the Utah station:

The beet plat was one-twentieth of an acre in area. Barnyard manure was applied at the rate of 20 tons per acre during the winter of 1901–02. The plat was plowed 10 inches deep and subsoiled 8 inches deeper on May 12, 1902. It was harrowed immediately afterwards and seeded on May 14, at the rate of 15 pounds of seed per acre, the rows being 20 inches apart. The beets were thinned and cultivated on June 14, and were irrigated on June 11 and on August 14, being cultivated two days after each irrigation. On August 2 the crop was reported to be looking well, with a medium stand, and tops 14 inches high. The irrigation water was not accurately measured, but was not far from 7 inches in depth over the whole plat at each irrigation.

Agricultural and analytical data determined at Logan, Utah.

Date of harvest.	Average weight of beets.	Yield per acre.[a]	Sugar in juice.	Sugar in beet.[b]	Purity coefficient.
1902.	*Ounces.*	*Tons.*	*Per cent.*	*Per cent.*	
September 25	11.48	13.8	15.01	13.8	80.26
September 30	12.08	12.4	13.50	12.4	76.70
October 6	9.87	11.6	14.04	12.9	81.15
October 13	13.20	10.9	14.82	13.6	86.66
October 28	18.59	23.5	15.40	14.2	77.38
Average	13.0	14.4	14.6	13.4	80.43

[a] Approximate estimate made at Washington, D. C. [b] Calculated at Washington.

Only the temperature and precipitation records were available for Logan, and in connection with these a full set of meteorological data for Salt Lake City, about 66 miles south of the experiment station, is given.

Meteorological data for Logan, Utah.

Month.	Mean temperature.	Precipitation.
1902.	°F.	*Inches.*
May	55.5	2.19
June	65.4	.74
July	68.4	.52
Average and total	59.8	3.45
August	70.5	.27
September	60.4	Trace.
October	41.4	.51
Average and total	60.8	.78
General average and sum total	60.3	4.23

Meteorological data for Salt Lake City, Utah.

Month.	Mean temperature.	Precipitation.	Sunshine.			Clear days.	Cloudy days.
			Actual.	Possible.	Per cent.		
1902.	°F.	Inches.	Hours.	Hours.			
May	59.2	0.33	308.0	449.1	69	15	6
June	69.4	.37	367.1	451.9	81	19	2
July	72.5	.56	372.4	458.6	81	22	4
Average and total	67.0	1.26	.....	.....	77	56	12
August	74.6	.15	330.4	427.4	77	19	3
September	64.1	.05	302.4	374.0	81	20	5
October	55.2	.52	280.6	343.9	82	21	5
Average and total	64.6	.72	.....	.....	80	60	13
General average and sum total	65.8	1.98	.....	.....	78.5	116	25

The results of the collaborative experiments at Utah show the production of a crop of about average tonnage, or at least what the average tonnage should be, a fair content of sugar, and a purity which reaches the standard for successful and profitable sugar manufacture.

The average temperature of the six growing months was 60.3°. August was the warmest month, its average temperature being 70.5°, while October was quite cool, having an average temperature of 41.4°. The precipitation was deficient except for the month of May, and the total amount of rainfall was only 4.23 inches for the six months.

GENERAL REMARKS.

The data from the irrigated sections are interesting in many respects as compared with those from the stations where irrigation is not practiced. In the first place it is evident that the extremes of heat which are experienced in the nonirrigated areas are avoided at the irrigated stations where the temperature is more equable, less prone to reach extreme maxima, and thus should be favorable, according to the results of our investigation, to securing a high content of sugar. And the figures show that the average percentage of sugar in the beets from the irrigated areas is 2.4 per cent higher than that of the other stations.

There was a marked deficiency in the rainfall at the California stations, while in Colorado the total amount of rain would have been sufficient to produce a fair crop had it been properly distributed throughout the growing season instead of one-half of it falling in a single month, namely, September, when it would probably be detrimental to the maturing of the beet.

By reason of the high altitudes there is danger of unseasonable lowering of the temperature, as was shown especially in Colorado, where severe frosts sufficient to check growth occurred in September. It is evident that latitude abstractly has little to do with the climatic con-

ditions which prevail in most of the arid areas because by reason of the influence of the sea on the western coast and the high altitudes of the plateaus, which form the greatest part of the surface of the arid States, the isothermal lines are greatly disturbed in their relation to the parallels of latitude. We have thus introduced into the study of these stations a seriously disturbing factor, the influence of which must be determined by further investigation. The more extensive data which we hope to receive during the next two years from these irrigated areas will form a basis for the solution of this important question.

As only three of the irrigation stations took part in the experiment and the work has only just been systematically inaugurated no attempt is made to represent the data collected in graphic form.

THE SOILS.

The following data, reported by the cooperating stations in regard to the soils on which the beets were grown, are submitted, although they are of rather a fragmentary character. Nevertheless, they are of interest in connection with the chemical and mechanical analyses of such samples as were received for 1902 and the data obtained in 1901.[a]

DESCRIPTIVE NOTES ON SOILS.

UNIRRIGATED SOILS.

AGRICULTURAL COLLEGE, MICH.

[Nos. 25106 and 25107.]

Director Smith sent the following notes on the sampling of soils at the Michigan station:

The experimental plat is from the center of a larger plat which has borne no crop at all since 1900. We made an attempt to get the soil sample from another part of the plat, but found the conditions so irregular that we had to go to another part of the area. Here we found the soil proper to be but 6 inches deep, the depth of the plowing for the years the plat has lain fallow. The subsoil was rather irregular, as it is bound to be here in the glacial region. A few years ago I made a topographical survey of certain plats on this area on which the varying yields of contiguous plats had indicated some peculiar conditions, and found that the subsoil rose and fell in waves, the crests of which were approximately a rod apart with a height of 6 feet.

The experiments were made on Nos. 33 and 35 of the station plats. These plats are 8 rods long and 2 rods wide. A subplat 60 feet on each side was laid off on the southern part of the plat, the south line being approximately the south line of the plats and the east line of plat No. 33. From the center of this plat a sample of soil was taken for analysis at Washington. From 1891 to 1899, inclusive, oats were grown on these plats with the exception of the years 1893 and 1899, when wheat was planted.

[a] U. S. Dept. Agr., Bureau of Chemistry Bul. 74, The influence of soil and climate upon the composition of the sugar beet.

ITHACA, N. Y.

[Nos. 24898 and 24899.]

The soil used for this year's experiment is a gravelly loam. It lays at the foot of a knoll and is naturally more fertile than the average soil of the field, but it has had no manure for several years.

GENEVA, N. Y.

[Nos. 1754 and 1755 S. and F].

The soil on which the beets were grown is a clay loam used in a five-year rotation, as follows: 1897, oats; 1898, wheat seeded to clover and timothy; 1899, clover and timothy, first cutting; 1900, clover and timothy, second cutting; 1901, Indian corn or maize.

BLACKSBURG, VA.

[Nos. 25104 and 25105.]

The character of this soil, its fertilization, etc., have been described under the agricultural data given for the Virginia station. The detailed account of the taking of the soil samples as forwarded by Mr. Alwood is as follows:

Opening No. 1.—The top soil, 10 inches deep, grayish, dark, almost slate colored, shows many pebbles and a considerable quantity of humus present. Soil is very mellow down to the subsoil. The line of demarcation between the soil and the subsoil is very distinct. The subsoil at this place is an ochreous yellow, decidedly clayey in texture, and quite moist, firm, but not hard.

Opening No. 2.—The top soil, 12 inches deep, had the same color and appearance as the above; very mellow, humus matter quite abundant, line of demarcation very distinct. Subsoil, gray in color and of very fine texture, was compacted into a tight hardpan, extremely dry and very hard.

Opening No. 3.—The soil was the same as No. 2, 12 inches deep. The subsoil was still harder than No. 2, very dry and with the same general color.

The season was extremely dry and it appears that the ground water failed to rise through the subsoil at the last two openings. At the first opening the ground water was very evident in the subsoil.

MADISON, WIS.

[Nos. 25108 and 25109.]

The soil is a clay loam with a heavy clay subsoil. It has a strong tendency to bake after rains, a thick solid crust being then formed on the surface.

IRRIGATED SOILS.

POMONA, CAL.

At Pomona station the sugar-beet soil is a sandy loam, free from alkali. The chemical character of the soil is the same as that of the Pomona station tract in general, except that it is more diluted from the admixture of a larger proportion of sand, thus diluting the plant

food to some extent. An analysis of the soil from the beet plat is as follows:

	Per cent.
Coarse materials > 0.55 mm	33.00
Fine earth	66.00
Chemical analysis of fine earth:	
Insoluble matter	68.40
Soluble silica	10.29
Potash (K_2O)	.89
Soda (Na_2O)	.42
Lime (CaO)	2.53
Magnesia (MgO)	1.84
Oxid of manganese (Mn_3O_4)	.02
Peroxid of iron (Fe_2O_3)	7.13
Alumina (Al_2O_3)	4.41
Phosphoric acid (P_2O_5)	.23
Sulphuric acid (SO_3)	.03
Carbonic acid (CO_2)	.08
Water and organic matter	8.21
Total	99.48
Humus	.58
Humus ash	.40
Humus nitrogen (per cent in humus)	1.16
Soluble potash (citric acid method)	.058
Soluble phosphoric acid (citric acid method)	.05

At Chino station (unirrigated) the soil is somewhat heavier in character than at Pomona, and more retentive of moisture as well as more fertile. The tract has been subdivided and in each subdivision the alkali content has been determined.

FORT COLLINS, COLO.

[Nos. 25060 and 25061.]

The following comments on the soil conditions existing at the Colorado station are taken from the report made by Mr. Danielson:

The ground on which these beets were grown was planted to potatoes the previous season (1901). The potatoes had received no water and only one cultivation. On the west side of the plats the potatoes had been fertilized with bone meal and nitrate of soda in strips running north and south. The beets were planted across these fertilized strips, so as to give all the varieties uniform treatment.

A mass analysis is given of soil from the station farm from a field not far distant from the one on which these beets were grown, and probably very similar. The analysis was made by W. P. Headden.

	Per cent.
Silicic acid	69.356
Sulphuric acid	.041
Carbonic acid	.016
Chlorin	.006
Phosphoric acid	.466
Potash	2.248
Soda	1.215

	Per cent.
Lime	1.645
Magnesia	1.412
Ferric oxid	5.424
Manganic oxid	.160
Moisture at 110° C.	2.981
Ignition	4.044
	100.352
Oxygen eq. chlorin	.001
	100.351

Samples of the soil and subsoil taken in the middle of the growing season from the area on which these beets were grown were forwarded to Washington.

ANALYSES OF SOILS.

The chemical and mechanical analyses of the samples of soils and subsoils forwarded to Washington from the various stations were made in the Bureau of Chemistry and in the Bureau of Soils of this Department, respectively, and the results are shown in the following table:

Chemical analyses of sugar-beet soils, 1902.

[Percentages based on water-free soil.]

Serial No.	Locality.	Description.	Insoluble.	Volatile.	Nitrogen (N).	Soluble in 1.115 sp. gr. HCl.					Soluble in N/200 HCl. Parts per million.	
						Potash (K_2O).	Lime (CaO).	Magnesia (MgO).	Fe_2O_3, Al_2O_3, Mn_3O_4.	Phosphoric acid (P_2O_5).	Phosphoric acid (P_2O_5).	Potash (K_2O).
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*		
25100	Lexington, Ky.	Soil	80.96	8.25	0.24	0.28	0.75	0.40	8.48	0.75	7.0	51.6
25101	do	Subsoil.	85.20	5.58	.14	.08	.59	.35	7.44	.50	.....	.....
25106	Agricultural College, Mich.	Soil	89.40	4.85	.11	.25	.62	.36	4.50	.09	2.0	37.0
25107	do	Subsoil.	92.79	2.15	.03	.28	.38	.39	3.20	.03	.....	.....
24898	Ithaca, N.Y. (Cornell).	Soil	87.58	7.30	.17	.21	.35	.45	3.09	.18	10.7	114.0
24899	do	Subsoil.	83.74	4.00	.06	.66	2.00	.84	8.03	.09	.....	.....
1754 (S. & F.)	Geneva, N. Y.[a]	Soil	81.70	8.00	.17	.56	.56	.82	8.34	.09	1.0	87.0
1755 (S. & F.)	do	Subsoil.	80.35	5.60	.10	.89	.81	1.27	10.91	.09	.....	.....
25104	Blacksburg, Va.	Soil	87.03	4.32	.17	.30	.19	.38	6.67	.14	5.0	249.6
25105	do	Subsoil.	87.30	2.90	.03	.36	.16	.47	8.62	.07	.....	.....
25108	Madison, Wis.	Soil	85.76	5.80	.13	.38	.61	.45	5.52	.16	26.0	48.0
25109	do	Subsoil.	85.30	5.00	.06	.44	.46	.67	8.00	.11	.....	.....
25125[b]	Washington, D.C.	Soil	83.47	5.35	.18	.39	.47	.51	8.27	.03	.....	.....
	Irrigated soils.											
25060	Fort Collins, Colo.	Soil	73.01	10.20	.18	.73	5.40	1.11	9.01	.18	3.5	141.0
25061	do	Subsoil.	65.39	12.50	.11	.54	10.16	1.27	9.35	.17	.....	.....
1756 (S. & F.)	Logan, Utah[c]	Soil	78.46	13.50	.10	.73	6.82	4.34	6.27	.22	25.0	391.8

[a] Samples taken after crop was grown.
[b] Analysis made in 1901. Same plat planted in 1902. Soil only analyzed.
[c] No subsoil sent, as plat is very shallow and underlaid with gravel.

Mechanical analyses of sugar-beet soils, 1902.

Serial No.	Locality.	Description.	Organic matter.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			Per ct.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
25100	Lexington, Ky	Soil	3.08	0.06	1.30	1.36	1.04	1.76	75.90	18.58
25101	do	Subsoil	1.43	0.00	.98	.50	.56	1.24	76.72	19.10
25106	Agricultural College, Mich	Soil	2.58	2.30	4.48	9.16	33.96	14.36	27.12	8.62
25107	do	Subsoil	.54	1.14	4.84	9.80	32.80	16.88	21.06	13.48
24898	Ithaca, N.Y. (Cornell).	Soil	3.42	.60	5.80	6.50	27.20	24.84	20.30	14.88
24899	do	Subsoil	1.34	0.00	3.08	3.90	31.06	34.00	17.46	10.26
1754 (S. & F.)	Geneva, N. Y	Soil	2.22	4.88	4.36	3.36	10.26	17.98	29.84	29.30
1755 (S. & F.)	do	Subsoil	.68	3.10	4.40	3.50	9.80	16.80	27.10	35.02
25104	Blacksburg, Va	Soil	1.82	3.56	3.52	2.44	6.58	10.10	58.62	15.18
25105	do	Subsoil	1.23	3.68	3.00	2.36	5.70	8.84	55.64	20.78
25108	Madison, Wis	Soil	3.14	0.00	1.30	2.20	7.40	6.40	65.50	16.74
25109	do	Subsoil	.78	0.00	.80	1.40	5.62	6.00	65.60	20.56
25125[a]	Washington, D.C.	Soil	1.63	.34	1.52	2.94	16.78	24.00	33.02	21.40
	Irrigated soils.									
25060	Fort Collins, Colo	Soil	2.52	.08	3.28	3.14	13.92	24.26	36.12	19.20
25061	do	Subsoil	1.09	.06	2.28	1.98	9.48	22.20	38.86	24.90
1756 (S. & F.)	Logan, Utah	Soil	5.83	1.10	1.60	1.94	22.80	35.16	22.58	14.80

[a] Analysis made in 1901. Same plat planted in 1902. Soil only analyzed.

COMMENT ON ANALYSES.

The data of the soil analyses are calculated to the water-free substances with the exception of water of composition. A general comparison of the soils of the irrigated and nonirrigated stations shows a larger percentage of insoluble matter in the first named than in the latter. On the other hand, the irrigated soils show a larger percentage of volatile matter than the nonirrigated. It is evident that the irrigated soils are more highly basic and the nonirrigated soils more highly acidic in character. The irrigated soils have a much higher average percentage of potash than the nonirrigated, and, with the exception of the soil from Lexington, they have a higher average content of phosphoric acid. The most marked difference, however, in the two sets of soils is in the quantity of lime contained, the irrigated soils showing a very much larger proportion of this important element. This is easily explained when it is remembered that lime compounds, especially the carbonate, are quite soluble in water carrying carbon dioxid, and thus the lime is more thoroughly leached from rain washed, nonirrigated soils. The large quantities of lime and potash present in the irrigated soils can not fail to be of lasting benefit to such a crop as the sugar beet. Potash furnishes a most important part of the food of the beet, while the lime tends to favor the conditions producing maximum nitration of the organic nitrogenous bodies which the soil may contain.

The irrigated soils, when treated with dilute cold hydrochloric acid, show larger quantities of potash than the nonirrigated, with the excep-

tion of the soil from Blacksburg, Va. The latter soil, although it does not have a very large percentage of potash, evidently holds it in a state easily assimilated by growing crops.

The nitrogenous content of the soils is quite uniform, but in some of the subsoils, as for instance those from Michigan and Virginia, the content of nitrogen is very low. Phosphoric acid is not very abundant in any of the soils except that from Lexington, Ky., which is well known as a carrier of large quantities of this important plant food.

The mechanical composition of the soil shows some interesting variations in the distribution of the materials of different degrees of fineness. The soil from the Lexington station is found to be three-fourths silt while that from the Ithaca station is only one-fifth silt. The soil from the Geneva station, where the richest beets are produced, is composed of almost one-third silt. In general it may be said that so large a proportion of silt as is found in the Lexington soil would tend to produce a seed bed somewhat too compact for the development of a beet of the best quality. Yet we find in the soil from Madison, Wis., that the percentage of silt is only 10 per cent less than that at Lexington. The yield of beets, however, at Madison and the content of sugar therein were both extremely satisfactory.

The organic matter varied greatly in the different soils, being present in the largest quantity in the sample from Logan, Utah, and the smallest in the soil from Washington, D. C., the latter being an artificial soil made from the materials dredged from the bottom of the Potomac River. Among the subsoils the one having the least organic matter was that from the Michigan station and the highest content was found in the sample from the Kentucky station.

SUMMARY OF DATA.

Agricultural and analytical data, 1902.

Station.	Mean weight of topped beets.	Estimated yield per acre.	Sugar in beet.	Coefficient of purity.
	Ounces.	*Tons.*	*Per cent.*	
Lexington, Ky	8.0	8.9	7.3	70.9
Washington, D. C	22.9	26.1	8.4	72.4
Blacksburg, Va	15.4	[a]16.7	11.7	74.4
Ithaca, N. Y	17.0	18.0	12.5	81.9
Madison, Wis	24.2	31.8	12.7	82.0
Agricultural College, Mich	10.6	12.5	13.5	86.9
Geneva, N. Y	14.3	16.1	13.9	84.5
Irrigation stations.				
Fort Collins, Colo	19.7	24.0	13.0	79.4
Logan, Utah	13.0	14.4	13.4	80.4
Pomona, Cal	.....	5.0	15.0	86.5

[a] Estimated on 50 feet of row harvested September 1 and 19.

Yield and soil data, 1902.[a]

Station.	Yield per acre.	Chemical analysis.			Mechanical analysis.		
		Potash.	Nitrogen.	Phosphoric acid.	Total sand.	Silt.	Clay.
	Tons.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Lexington, Ky	8.9	0.18	0.19	0.63	4.37	76.81	18.84
Agricultural College, Mich	12.5	.27	.07	.06	63.14	24.09	11.05
Geneva, N. Y	16.1	.73	.14	.09	35.23	28.47	32.06
Blacksburg, Va	16.7	.33	.10	.11	21.27	57.13	17.98
Ithaca, N. Y	18.0	.44	.12	.14	68.19	18.88	12.57
Washington, D. C.[b]	26.1	.39	.18	.03	45.24	33.02	21.40
Madison, Wis	31.8	.41	.10	.14	15.56	65.55	18.65
Irrigated soils.							
Pomona, Cal.[c]	5.0	.89	.....	.23	.....	.....	.....
Logan, Utah[d]	13.0	.73	.10	.22	61.50	22.58	14.80
Fort Collins, Colo	24.0	.64	.15	.18	40.27	37.49	22.05

[a] Average of figures for soil and subsoil as platted on charts are given.
[b] Soil only for 1901.
[c] Determined at California station; only humus nitrogen given.
[d] Soil only.

Meteorological data, May to October, 1902.

Station.	Temperature.	Precipitation.	Clear days.	Cloudy days.	Sunshine.
	°*F.*	*Inches.*			*Per cent.*
Lexington, Ky	69.3	16.6	83	22	76.1
Washington, D. C	68.6	23.5	80	25	67
Blacksburg, Va	65.8	15.2	74	46	.....
Ithaca, N. Y	60.4	23.3	41	54	.....
Madison, Wis	61.8	24.6	38	76	.....
Agricultural College, Mich	60.5	27.4	55	67	[a]58
Geneva, N. Y.[b]	63.1	20.2	.....	.....	.....
Irrigation stations.					
Fort Collins, Colo	60.0	14.8	94	32	[c]62.5
Logan, Utah	60.3	4.2	[d]116	[d]25	[d]78.5
Pomona, Cal	70.0	.59	67	6	[e]70

[a] Sunshine data for Detroit, Mich.
[b] Data for May observed at Lyons.
[c] Sunshine data for Cheyenne, Wyo.
[d] Report for Salt Lake City, Utah.
[e] Report for Los Angeles, Cal.

Geodetic data.

Station.	Average length of day.[a]	Latitude.[b]	Altitude.[b]
	h. *m.*	° ′ ″	*Feet.*
Lexington, Ky	14 18	38 02 25	979
Washington, D. C	14 23	38 53 23	37.5
Blacksburg, Va	14 14	37 14 00	2,100
Ithaca, N. Y	14 41	42 27 00	810
Madison, Wis	14 44	43 04 36	955
Agricultural College, Mich	14 42	42 45 00	847
Geneva, N. Y	14 44	42 53 00	458
Irrigation stations.			
Fort Collins, Colo	14 32	40 35 00	4,994
Logan, Utah	14 37	41 44 00	4,506
Pomona, Cal	13 58	34 3 00	861

[a] These figures cover from May to August, inclusive, and are furnished by the U. S. Naval Observatory.
[b] Data furnished by the U. S. Coast and Geodetic Survey.

CONCLUSIONS.

The results of the investigations of 1902 confirm in a general way those of the two previous years. As is to be expected, however, the great seasonal changes which take place from year to year at the different stations introduce important variations in the chemical composition of the crop. For the third time in succession, however, the station at Geneva holds first place in respect of the content of sugar.

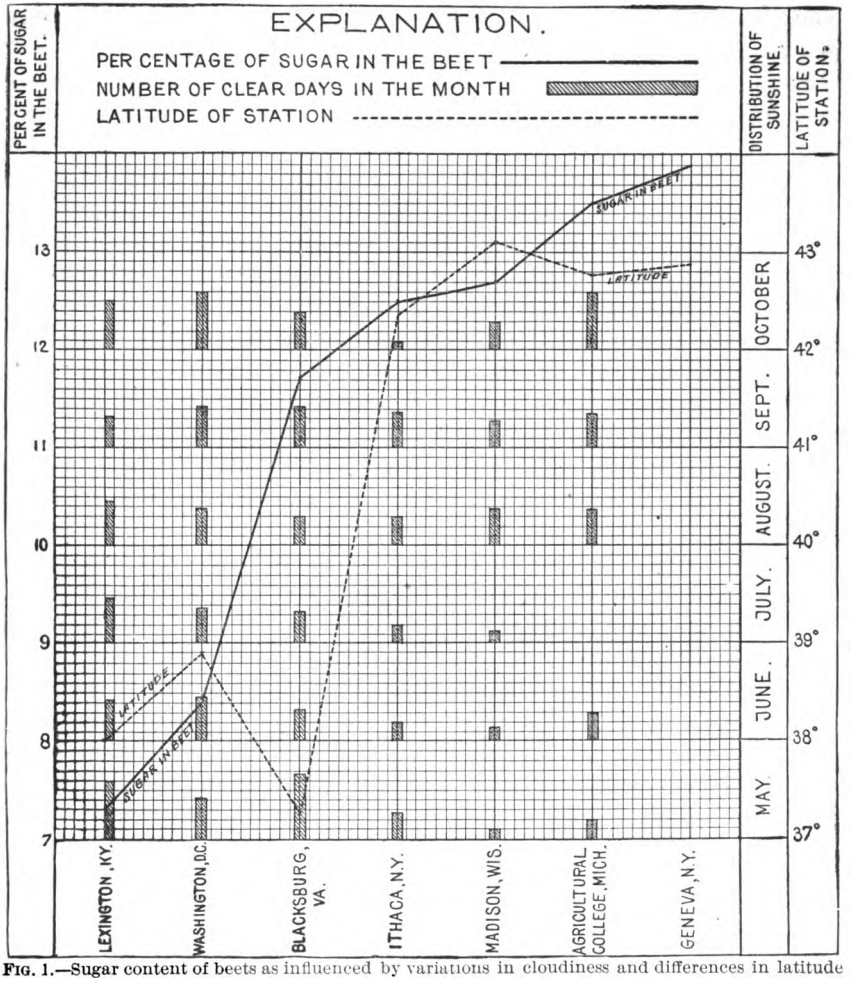

FIG. 1.—Sugar content of beets as influenced by variations in cloudiness and differences in latitude of experiment stations.

Michigan has advanced to second place, after having been tied with the stations of Ithaca and Lafayette in 1901, for that position.

The chart (fig. 1) shows the percentage of sugar in the beet, the number of clear days in the month during the growing season, and the latitude of the station. By reason of the fragmentary nature

of the data for the percentage of sunshine the curve representing this element of the environment has been omitted. As in the two previous years, there is a general agreement in the curves showing the percentage of sugar and the latitude. The one important exception is found in the Blacksburg station, and this is fully explained by reason of the high altitude of this locality, which acts in the same manner as a high latitude. Were it not for the varying length of the day a more definite relation could be established by comparing the sugar content of the beet with the mean isothermal lines for the period of growth, instead of with the latitude.

The number of clear days was very evenly distributed between the growing months at Lexington, Washington, and Blacksburg and quite unevenly distributed at the other stations for which these data were reported. In our previous reports attention was called to the fact that unobstructed sunshine is not absolutely necessary to the normal development of the sugar content of the beet.[a] Some recent studies made in Germany on the influence of certain factors of the environment upon the composition and yield of sugar beets, by Dr. O. Vibrans, of Helmstedt,[b] confirm the conclusions published by this Bureau in regard to the effect of cloudy weather upon the quality of the beet.

The author states that it has long been supposed that in order to secure a normal evolution of the sugar beet and a favorable harvest continued warmth and sunshine are necessary in addition to the requisite moisture. The season of 1902, however, characterized as it was by excessive cloudiness and precipitation, showed that these conditions, especially as bearing upon the quality of the beet, are not necessarily detrimental. It is stated, however, that the result of the harvest showed a diminished yield in spite of the fact that a sufficient quantity of moisture was received during the growing season and although the fields were well cultivated, normally fertilized, and the beets carefully watched.

These observations bear out the conclusions which we have drawn from our studies to the effect that the sun's rays when the sky is covered with clouds are still able to influence the functional activity of the chlorophyll cells in such a way as not to diminish the percentage of sugar in the beet. In fact during the very hot days of summer such a screening of the sunlight may prove beneficial. Vibrans says:

> The weakening of the total intensity of the sun's action by the particles of water and dust which may be in the air is greatly increased in the case of clouds. If a cloudy condition continues for some time the sun's rays nevertheless, as has been said, continue to exert their influence on the plant. This has been shown by the peculiar phenomena which were manifested during the past year (1902), when it was

[a] U. S. Dept. Agr., Bureau of Chemistry Bul. 64, p. 30, and Bul. 74, p. 37.

[b] Centralblatt für die Zucker-Industrie, No. 33, May 16, 1903, p. 809, and No. 34, May 23, p. 829.

noticed that those sugar beets which were particularly rich in sugar had developed an excessive leaf growth. From this the conclusion can be drawn that the leaves which were at first developed by the beet were not sufficient to produce a normal development with the quantity of light at their disposal. The dormant buds, therefore, woke into activity and produced the additional leaves required. Thus a more extended leaf surface was created and the light could thus engender the necessary activity to develop new vital processes.

It is further shown that this increase of leaf surface which permits the assimilation process to go on unhindered in cloudy weather is not noticed in conditions of artificial shade which tend to produce etiolation—as, for instance, on the edges of forests. In such cases the leaf stems are unduly lengthened, thin, and weak, and the leaves do not reach normal size because those processes in the leaf cells which promote the formation of leaf surface do not develop normally. The result of this is that the processes of assimilation and condensation attending the activity of the chlorophyll cells in the formation of starch and sugar are not complete. Greater comparative quantities of nonsugars are formed and the value as well as the quantity of the beets produced is greatly diminished. The size of the beet leaf in relation to the stem is dependent on the quantity and intensity of the light, and the more refractive elements of the sun's rays appear to be most active in producing such growth.

In the case cited by Vibrans as to the effect of artificial shading of beets grown along a road bordered by thick, heavy, chestnut trees, he states that the beets not only had a lower sugar content, but also yielded a decreased tonnage. It appears, however, that Vibrans has probably fallen into some error in ascribing this diminution of both sugar content and tonnage solely to the shade of the trees. It is well known that trees draw upon the adjacent soil for nourishment and to this extent rob any cultivated plant that may be in the vicinity. A large number of the poorer quality of beets in that experiment may have been due, therefore, to the absorbing activity of the rootlets of the trees extending great distances under the growing crop.

On the chart (fig. 2, p. 44) are shown the percentage of sugar in the the beet, coefficient of purity of the juice, the temperature and the average length of day. Here again is seen the X-like figure—somewhat fantastic in shape this year, but still marked in character—formed by the lines representing the content of sugar, purity of juice, and length of day, with the line representing the temperature. The variations in the temperature curve are found chiefly at Ithaca and Geneva. At Geneva, especially during the present year, the temperature of the growing season was high, while at Ithaca it was the lowest of any recorded at the cooperating stations. The highest temperature observed was at Lexington, Ky. The data represented on Chart No. 2 are in general wholly confirmatory of those obtained in the previous years of the investigation.

On the chart (fig. 3, p. 45) are shown the percentage of sugar in the beet, the total rainfall and its distribution by months throughout the

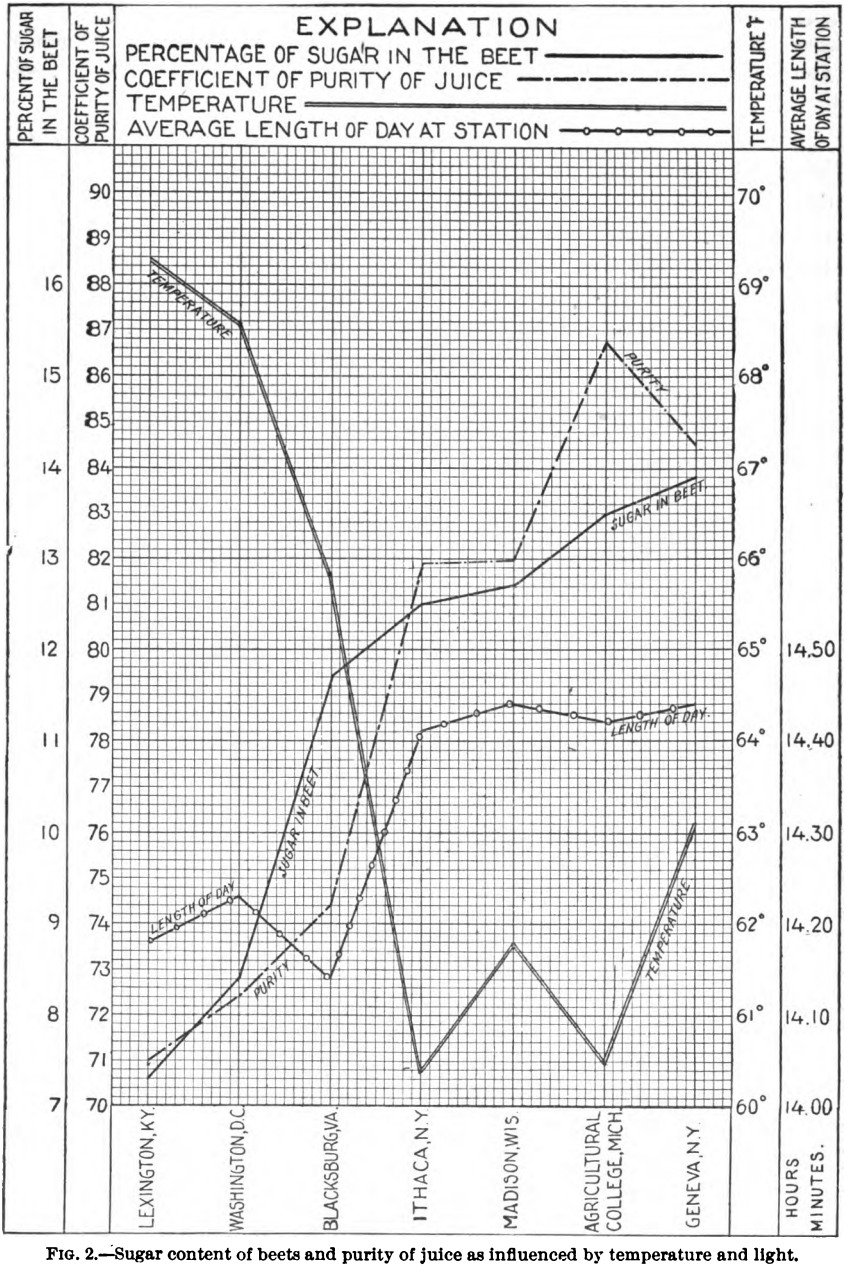

FIG. 2.—Sugar content of beets and purity of juice as influenced by temperature and light.

growing season, together with the altitude of the station. The most characteristic feature of this chart is the monumental curve showing

the altitude of the Blacksburg station. It is evident that altitude can only be considered in connection with the content of sugar in the beet

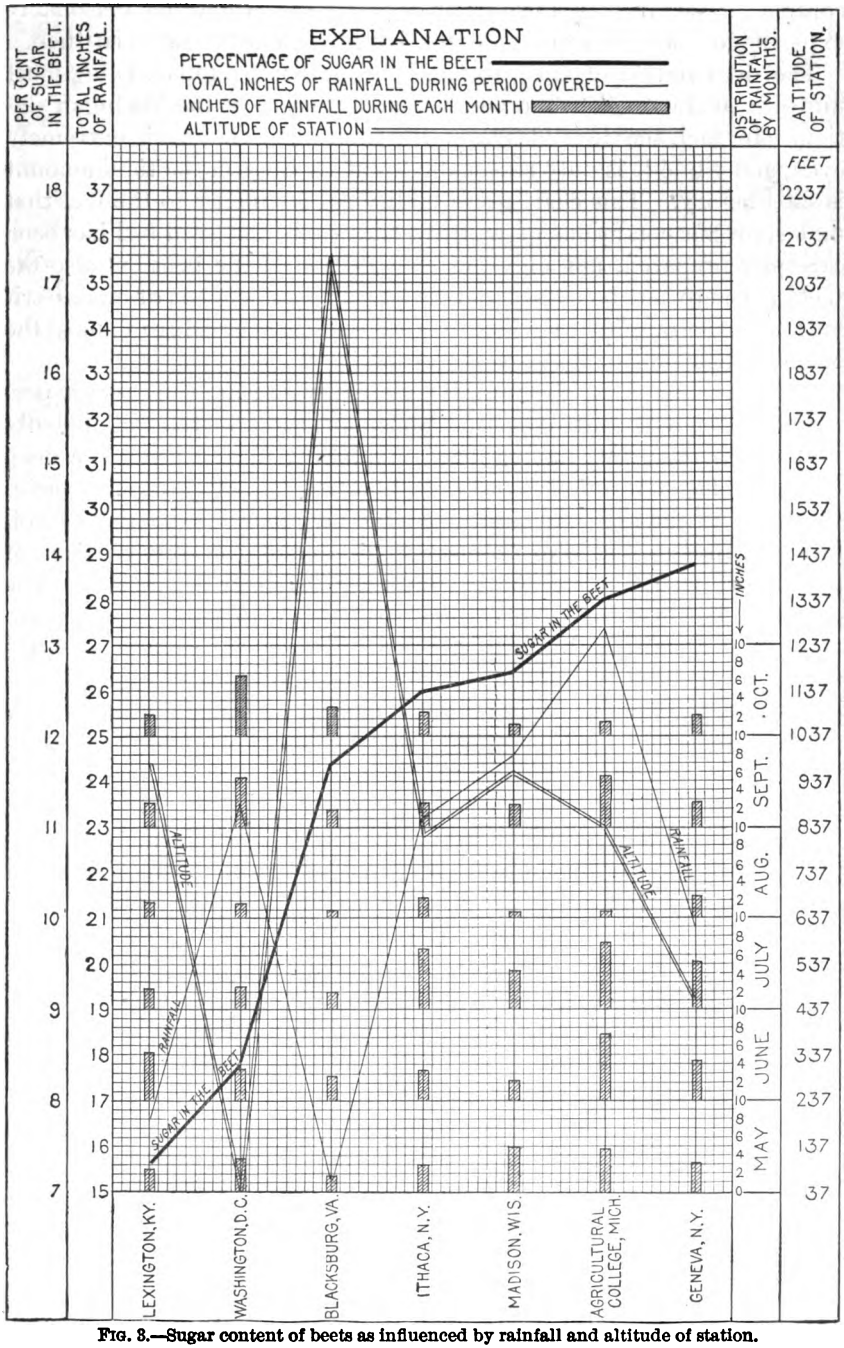

FIG. 8.—Sugar content of beets as influenced by rainfall and altitude of station.

when referred to some fundamental basis of comparison. there is a very marked tendency, however, for the high altitude to counteract

the influence of the low latitude. This is shown vividly by the chart in the case of Blacksburg, where by reason of the high altitude the content of sugar was raised far above what would be reasonably expected at sea level or on an extensive plateau at the same latitude.

The distribution of the rainfall is somewhat irregular, being most uniform at Lexington and Geneva, and least so at the Michigan station. In fact, the distribution of the rainfall at Geneva is extremely even, and while it is only reasonably so at Lexington the total amount is satisfactory. This chart gives additional testimony to the fact that under proper conditions of culture, and where the seed bed has been carefully prepared, not only the composition of the beet but also the yield per acre can be considered as largely independent of the distribution of the rainfall, provided there is sufficient moisture to meet the ordinary demands of the growing crop.

The chart (fig. 4, p. 47) shows the yield per acre and the average percentages of potash, nitrogen, and phosphoric acid in the soil and subsoil, the two figures having been combined, as the beets are deep feeders. The determination of potash, nitrogen, and phosphoric acid, according to the methods used, gives only a general indication of soil fertility, though the total absence of any one of these ingredients of plant food would make the production of a crop impossible. The presence, however, of even a small proportion of these foods, reckoned in per cent, indicates a sufficient quantity for many successive crops, if rendered available. The weight of the soil is so great compared with the weight of the crop that is produced upon it that a very few hundredths of a per cent of any one ingredient of plant food means an abundance of this ingredient for the production of the normal crop, provided it is in a form available for plant growth. At the station which had the largest yield per acre, namely, Madison, Wis., the phosphoric acid content was higher than at any other station except Lexington and Ithaca, being the same as at the latter station. The quantity soluble in dilute acid, however, was larger in the Madison than in the Lexington sample. The amount of potash was higher than at any other station except Ithaca and Geneva, while the nitrogen was lower than at any other station except Agricultural College, Mich., being the same as that at Blacksburg, Va. The lowest average percentage of nitrogen at any one of the stations was 0.07 at Michigan, and the highest was 0.19 at Lexington.

The presence of large quantities of two of the important plant foods does not indicate a large crop if a third important plant food is very deficient. This is shown in a marked degree at the Lexington station, which has the highest percentage of both phosphoric acid and nitrogen and the lowest percentage of potash of any of the stations, accompanied by the lowest yield. The yield per acre at Lexington could doubtless be greatly increased by the judicious applica

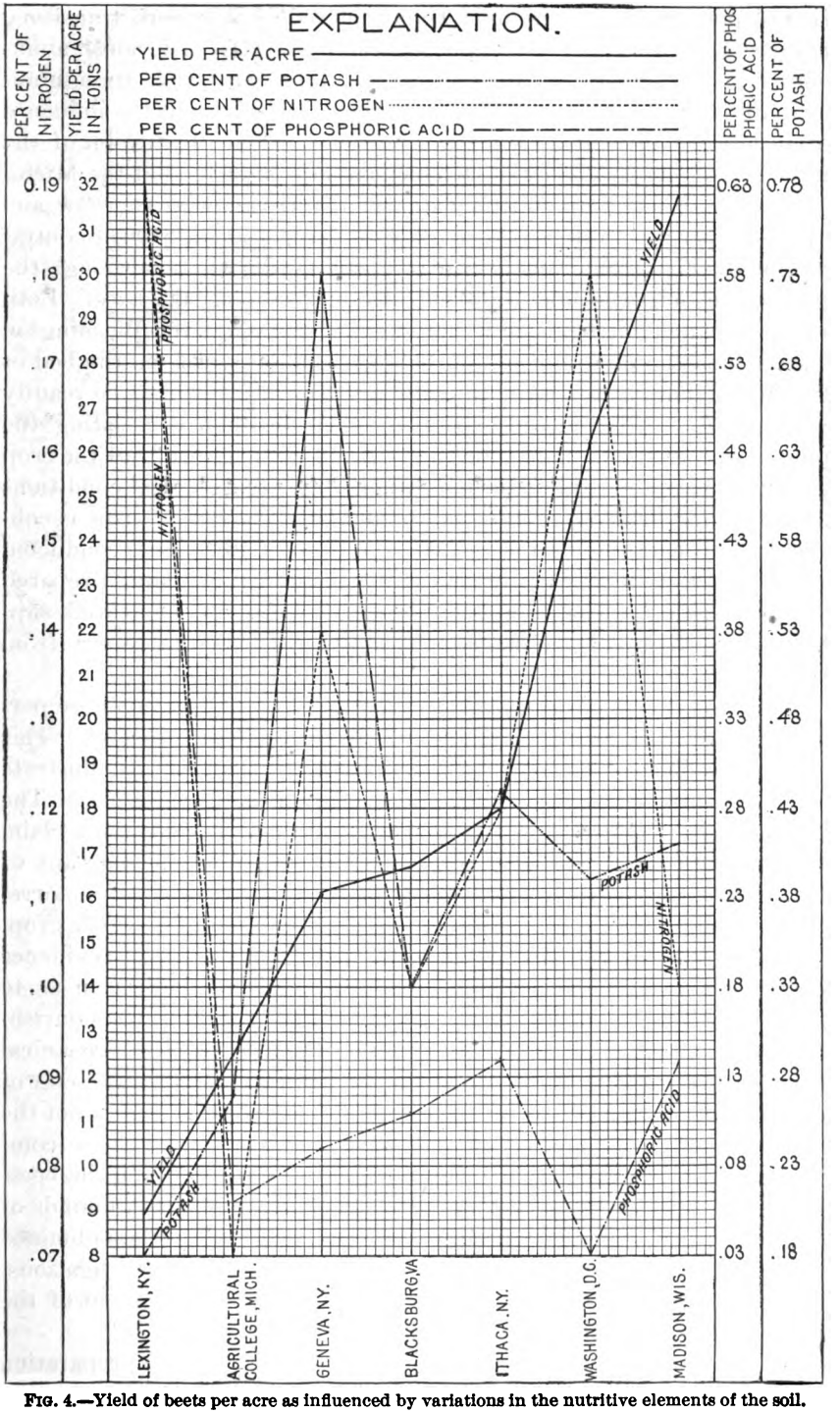

FIG. 4.—Yield of beets per acre as influenced by variations in the nutritive elements of the soil.

tion of potash. Nitrogen must be considered as of a more transitory nature than either potash or phosphoric acid. It exists most abundantly in the soils in the form of organic nitrogen which, though not available for plant food in that form, becomes so under the influence of nitrifying ferments. We have, however, a fine illustration of the influence of the deficiency of two elements of plant food at the Michigan station, where both phosphoric acid and nitrogen were very low, and the yield per acre was next to the lowest given. An apparent contradiction of this is found in the case of Washington, where, although the phosphoric acid was low, the yield was over 26 tons per acre. Both the potash and nitrogen, however, were abundant at the Washington station, and the phosphoric acid, having been derived from the bed of the river, though not large in quantity, was in a form to be readily assimilated. It is evident, however, that the data correlating the quantity of available plant food in a soil and the magnitude of the crop produced have their full value only when the meteorological conditions and all other elements of the environment are the same. This is convincingly illustrated by the results of the pot experiments conducted by this Bureau during the past decade which are now being prepared for publication. The complete failure of a crop on a soil well supplied with the necessary plant foods is described in the report from the Indiana station this year.

The chart (fig. 5, p. 49) shows the yield per acre and the average percentages of total sand, clay, and silt in the soil and subsoil. This chart, in so far as we know, is the first attempt to graphically illustrate the relation of the mechanical composition of the soil to the crop. The problem is so new and the data so fragmentary that we can not claim that much progress has been made in the attempt to elucidate any of the undeveloped principles, if there be such principles, which correlate the mechanical composition of the soil and the yield of the crop. It is evident that the mere mechanical state is not complete evidence of the availability of the plant food, but it is an indication as to whether or not the rootlets of the plant can have access to the nourishment which the soil contains. In general, it is true that the mechanical condition of a soil is highly important in determining the character of the crop which can be grown thereon. For instance, wheat is not the ideal crop for very sandy soils, nor melons and beets for those composed of stiff clay. We have, however, in the soils on which the beets of the present investigation were grown types of almost all kinds of soils, as far as mechanical structure is concerned, and the data obtained illustrate again, as has been developed in the former investigations, that the soil is the least important factor in the environment of the sugar beet in respect of sugar content.

A fundamental condition for the growth of beets is the preparation of the seed bed to a depth of at least 16 inches. Thus, even stiff clay

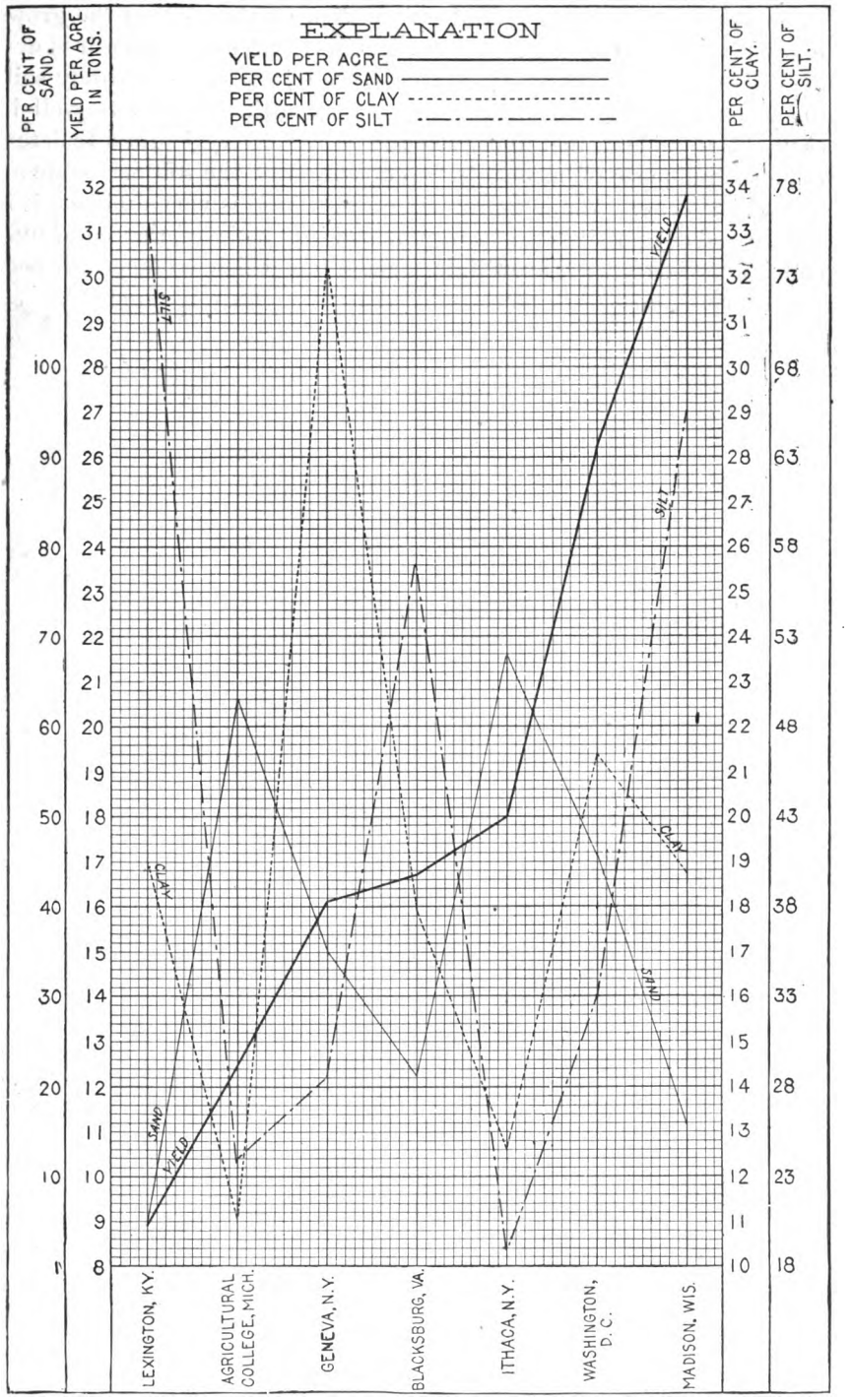

FIG. 5.—Yield of beets per acre as influenced by variations in physical composition of the soil.

when properly prepared is easily permeated by the roots of the growing beets. If a stiff clay soil be not properly prepared, then it is evident that beets could not do nearly so well in it as in a sandy soil; but when both kinds of soil are well prepared the beet grows well in each. It is evident, therefore, that the beet is not well suited to determine the influence of mechanical composition of the soil on the quantity of the crop. While a problem of this kind is very difficult, it is not beyond the possibility of solution, and it is believed that continued collection of data will throw light upon points which, so far as the beet is concerned, must now be considered as very dimly illuminated.

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U. S. DEPARTMENT OF AGRICULTURE.

BUREAU OF CHEMISTRY—BULLETIN No. 95.

H. W. WILEY, Chief.

THE INFLUENCE OF ENVIRONMENT UPON THE COMPOSITION OF THE SUGAR BEET, 1903.

BY

HARVEY W. WILEY,
CHIEF OF BUREAU.

IN COLLABORATION WITH THE WEATHER BUREAU AND THE AGRICULTURAL EXPERIMENT STATIONS OF CALIFORNIA, COLORADO, INDIANA, IOWA, KENTUCKY, NEW YORK (GENEVA AND ITHACA), OREGON (UNION), WISCONSIN, AND WYOMING.

WASHINGTON:
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1905.

LETTER OF TRANSMITTAL.

U. S. DEPARTMENT OF AGRICULTURE,
BUREAU OF CHEMISTRY,
Washington, D. C., May 25, 1905.

SIR: I have the honor to transmit for your approval a manuscript, accompanied by graphic charts, setting forth the results of the cooperative work conducted by this Bureau on the effect of environment upon the composition of the sugar beet during the year 1903. This is the fourth year of this work, the results of previous years being recorded in bulletins Nos. 64, 74, and 78 of this Bureau. The portion of the analytical work done in the Bureau on the beets was performed by Messrs. Church and Given and that on the soils by Messrs. Veitch and Trescot.

Respectfully,

H. W. WILEY, *Chief.*

Hon. JAMES WILSON,
Secretary of Agriculture.

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ILLUSTRATIONS

THE INFLUENCE OF ENVIRONMENT UPON THE COMPOSITION OF THE SUGAR BEET, 1903.

ORGANIZATION OF COLLABORATIVE WORK.

Under date of January 21, 1903, the following letter of instructions was addressed to 17 experiment stations, the majority of which had taken part in this cooperative work during the three previous years:

DEAR SIR: It is desired to continue the collaborative work in the study of the influence of environment on the composition of the sugar beet. For this purpose I send you, under separate cover, seed and shipping tags, and an outline of the work in which your assistance is requested.

If, after reading the outline of the experiments, you are willing to collaborate, please advise me to that effect as soon as practicable. If you can not collaborate, return the packages of seed, etc., using the franks inclosed to transmit the packages to this office, or use the seed as you may see fit. I am very anxious that you should collaborate in these experiments, since the data, to be of value, should come from many localities representing various climates. The following is an outline of the work desired:

Plant an area not exceeding an eighth of an acre unless a larger area or a number of plats is desired for station purposes. This matter is left to your own judgment, but it is suggested that the special plat be seeded very heavily so as to assure a good stand and that enough seed be reserved for replanting in case the first planting should not germinate.

The soil, some time before sowing, preferably the previous autumn, should have been plowed to the usual depth of 8 or 9 inches and subsoiled about 6 inches more, making a seed bed at least 15 inches deep. If the character of the soil warrants it, a deeper plowing, even to 10 or 11 inches, and a subsoiling of 6 inches additional, will be advisable. The surface of the soil should be reduced to a fine tilth, well harrowed, and stirred immediately before planting so as to stop all growth of weeds.

Make the rows 18 inches apart and plant the seed at the rate of about 25 pounds per acre, so as to insure a good stand. If the soil is moist, cover the seed to a depth of one-half to 1 inch; if the weather is dry, a slightly deeper planting is advisable. The plat should be as nearly square as practicable except in the event of planting a larger area.

As soon as the plants are vigorously growing they should be "bunched" with a hoe—that is, separated into clumps by a hoe 6 inches in width, leaving the length of 3 inches of beets in each bunch. When the beets begin to form the fourth leaf they should be thinned to about one plant in each 9 inches. If the soil is very fertile the beets may be left closer together. Ordinary surface cultivation is all that is required, taking care not to cover up the beets at the first cultivation.

It is desired to make a careful analysis of the soils on which the beets are grown, and therefore you are requested to take representative samples of the soil and subsoil of the plat used for this experiment. After taking a representative sample, reduce it in size by quartering or otherwise, so as to obtain

a representative subsample weighing not more than 4 pounds. Accompanying the seed you will find bags for packing the soils, also shipping tags. Enter on the tag the name of your station, the words "Beet soil," the kind of soil, and the date. Also send a history of the plat as far as known. Complete cultural data and meteorological data, which may be obtained in collaboration with the Weather Bureau, are also desired.

One month prior to the usual time of harvest in your locality, begin harvesting beets from the experimental plat. Harvest every beet in 50 feet of an inside row, remove the leaves, clean the beets, and weigh them. Select 25 average beets, weigh them without topping, and forward them to this Bureau by express, collect. Inclose a slip in the package giving all weights and your estimate of the tonnage, based upon the weight of beets from 50 feet of row. Repeat this sampling once each week until frost prevents further operations, or, as in California, the beets begin to deteriorate.

It is urged that these directions be implicitly followed, since the outcome of the work depends upon the care and uniformity with which the agricultural work and the sampling are done. If practicable, I shall be glad to have check analyses made at your station, and during the progress of the analytical work the results obtained here will be reported to you for comparison.

The stations where irrigation is practiced were requested to report the dates of irrigation, the amount of water applied each time, and any other details relating to this special phase of the experiment.

The seed used in this experiment was furnished by the Seed Laboratory of the Bureau of Plant Industry, with the following description: Kleinwanzlebener beet seed received from E. H. Morrison, Fairfield, Wash., January 17, 1903; germination test gave 80.5 per cent of seed balls, and 161 sprouts from 100 balls.

Reports are given from only ten stations besides Washington, D. C. The data in some cases are somewhat fragmentary, but are placed on record for consideration in connection with the work of the other four years of the experiment. Several of the stations which planted the seed did not complete the work, the crop in California being a failure, while, through a misunderstanding, the necessary analytical data and samples were not received from the stations in Virginia, Michigan, and Utah, and they are therefore excluded from the report of this year's work. The stations reporting results are those of Colorado, Iowa, Indiana, Kentucky, New York (Geneva and Ithaca), Oregon (Union), Wisconsin, and Wyoming.

EXPERIMENTS CONDUCTED IN HUMID REGIONS.

POTOMAC FLATS, WASHINGTON, D. C.

Under date of July 20, Mr. Beattie, assistant horticulturist of the Bureau of Plant Industry, made the following report on the beets being grown under his directions on the Potomac Flats branch of the Arlington Experiment Farm:

The four plantings on heavy soil, made at intervals of two weeks beginning April 20 and continuing until June 1, are on this date more uniform than at

this time last year. Owing to constant cold rains the seed did not germinate well and a rather poor stand resulted from the first two plantings. The foliage now almost covers the surface of the ground and no disease is apparent. The planting made on sandy soil on April 20 made a good stand, and the beets are considerably ahead of those on the other plats.

In general the season in Washington has been very late, and, while the rainfall has not been excessive, there has been more cold, rainy weather than usual. These conditions have delayed both the planting and cultivation of the crops very greatly.

The agricultural, analytical, and meteorological data obtained for this experiment are given in the following tables, the averages being determined on 15 samples taken weekly from August 7 to November 23:

Agricultural and analytical data on beets grown on the Potomac flats, District of Columbia, showing averages for different dates of planting.

SANDY SOIL.

Number of planting.	Date of planting.	Number of beets in 50 feet of row.	Weight after topping.		Estimated tonnage.	Sugar in juice.	Sugar in the beet.	Purity coefficient.
			Total.	Average.				
	1903.		*Pounds.*	*Ounces.*	*Tons.*	*Per cent.*	*Per cent.*	
First	Apr. 20	23	49.5	34.6	12.7	8.8	8.2	69.4

HEAVY SOIL.

First	Apr. 20	47	53.9	18	13.9	8.5	7.9	70.8
Second[a]	May 4	51	57.2	18.9	14.6	9.3	8.7	71.6
Third	May 17	52	52	16.2	13.3	9.5	9	70.8
Fourth	June 1	63	41.4	10.1	10.6	9.6	9	70.5

[a] Data for the second planting on heavy soil, that of May 4, are used in the graphic charts.

Meteorological data for Washington, D. C., 1903.

Month.	Temperature.	Precipitation.	Sunshine.			Clear days.	Cloudy days.
			Actual.	Possible.	Percentage.		
	° *F.*	*Inches.*	*Hours.*	*Hours.*			
May	64.4	2.75	285.1	443.8	64	17	7
June	67	3.60	175	445.9	39	5	15
July	76	5.17	324.8	453	72	19	3
Averages and totals	69.1	11.52	.....	.....	58	41	25
August	71.8	4.52	178.4	423.2	42	8	14
September	67.2	.74	265.1	373.4	71	16	5
October	56.8	4.48	189.4	346	55	16	9
Averages and totals	65.3	9.74	.....	.....	56	40	28
General averages and totals	67.2	21.26	.....	.....	57	81	53

The soil on which the beets were grown on the Flats, as has been mentioned in previous reports, has been made artificially by dredging the channel of the Potomac River. The method of dredging consists in pumping the mud from the bottom of the river, and the water mixed therewith, through pipes, collecting the mixture in ponds,

allowing the mud to settle, and removing the water either by drainage or by allowing it to percolate naturally through the soil or to evaporate. In some parts of the field, therefore, the surface is covered with sand, more or less pure, while in other sections the made soil consists of clay, organic matter, and more or less sand.

During the present season comparative determinations were made on the quantity and quality of the beets produced on the sandy soil and on the heavier soil just described. Only one planting was made on the sandy soil which may be compared with the planting made on the same date on the heavy soil. The yield on the heavy soil was a little over 1 ton more per acre than upon the sandy soil; the percentage of sugar in the beet was 0.3 per cent less, and the purity 0.9 higher. The later plantings on the heavier soils, however, show more favorable data. In all cases in the later plantings the percentage of sugar in the beet is greater and the purity higher than for the first planting. The yield per acre varied, being greater than the first planting on the plat seeded May 4 and less on the other two plats.

The rainfall was well distributed, though considerably more abundant in July than in May and somewhat too heavy in October. The general seasonal conditions were fairly good, but the yield was considerably less than in the previous year. The general character of the beets is practically the same as for the three preceding years, the most striking characteristics being low sugar content and purity.

THE INDIANA STATION.

A very complete report was received from Mr. W. J. Jones, jr., in charge of the beet work at the Indiana station, both on the general experiment and on a separate study that was made in comparing an irrigated and an unirrigated plat. The cultural data from the preparing of the soil in March to September 25 are as follows:

CULTURAL DATA.

March.—Plat plowed and harrowed.

May 1.—Plat harrowed both ways. Soil and subsoil sampled.

May 2.—Soil broken with clod crusher. Beets sown in the morning. Soil in excellent condition; temperature of soil 62° F. Area first planted, 71.5 by 296 feet; 13 pounds of seed used in planting and replanting. Part of the plat was planted in rows 18 inches apart and the remainder in rows 22 inches apart.

May 9.—Beets beginning to come through.

May 12.—Beets practically all up; apparently a good stand.

May 17.—Close examination reveals absence of beets in many places. Ungerminated seed found in soil.

May 18.—Plat resown where beets were thin.

May 28.—Resowing appears to have been of little value and stand is scattering.

June 2.—Beets transplanted to fill in rows. Most of rows planted 18 inches apart were so poor that they were abandoned and the experiment was continued with the rows which were planted 22 inches apart.

June 9–10.—Beets hoed and weeds removed. Grubworms at work in field.

June 17.—Beets thinned to distance of about 9 inches. Owing to transplanting it was difficult to get uniform distance.

June 25.—Beets cultivated. Plants look fine. Soil in excellent condition.

July 8.—Beets cultivated. Beetles working on leaves of plants. Foliage abundant. Plants in excellent condition.

July 17.—Soil loosened with plow and drill attachment. Weeds removed with hoe. Potato bugs in field.

August 3–24.—Beets making good progress. Plat free from weeds and soil in good condition.

August 24.—Beet leaves turning yellow in places.

August 31.—Leaf disease (Huston's Evil Eye) making its appearance. Leaves turning brown and wilting.

September 8.—Beets wilting. Leaf disease increasing.

September 12.—Plants sprayed with Bordeaux mixture.

September 14.—Beets maturing. Sample gave 12.8 per cent sugar in the juice.

September 21.—Sample gave 12.8 per cent sugar in the juice.

The foregoing applies not only to the plats which were cultivated without irrigation, but also to those on which the irrigation experiment was conducted.

The following additional comments relate to watering on the irrigated plats, and give comparisons of the irrigated and unirrigated crops:

July 1.—Rows ridged and hollows left for irrigation.

July 2.—Water equivalent to 1.63 inches was added to the entire plat. The plat was 77.5 feet by 18.3 feet, and required the addition of 118.4 cubic feet of water for each inch of depth.

July 9.—Water equivalent to 0.66 of an inch was added to the entire irrigated plat. The ground absorbed water rapidly. Both ground and beets are in excellent condition.

August 3.—Water equivalent to 1 inch was added to the entire field. This addition made the ground very wet. Beets in unirrigated plat look better than beets in irrigated. Lower leaves of beets in latter are turning yellow.

August 10.—Irrigated beets wilt during heat of day. Leaves drying up.

August 17.—Beets about as at last report.

August 24.—Beets making progress. Unirrigated look better than irrigated. Leaves of irrigated beets turning badly. Bugs in field.

August 31.—"Huston's Evil Eye" making its appearance. Irrigated beets are worst affected.

September 8.—Irrigated beets are showing bad effects of "Evil Eye."

September 12.—Entire field was sprayed with Bordeaux mixture.

REPORTS DURING THE HARVEST.

With each sample of beets sent from September 25 to November 29 full reports were made as to the condition of the crop, extracts from which are given below:

September 29.—We have had a great deal of difficulty with the cooperative beet experiments this year, due to two causes: (1) The plat on which we have been raising these beets does not seem to be in good condition for such a purpose, and (2) the seed did not germinate well. For this reason our plants were scattering, and it was necessary for us to transplant a large number. Those

which were transplanted are not perfect in form, having a tendency to multiplicity of roots. For this reason it is very questionable whether we can give a fair estimate of the yield.

October 4.—The plants are looking very well at present, and the leaf disease noted in previous years seems to have been checked. As yet we have found no beets affected with this disease, and they are also free from scab. The tendency to root multiplication mentioned in the last report does not seem to be due to transplanting, as was suggested, since the same defect is noticed in parts of the field where no beets were transplanted. Rains of over 1 inch during the past week will have a tendency to retard the maturing of the beets.

October 9.—While the beets are looking very well indeed, the weather since the taking of the previous sample has been unfavorable to maturing them. During the last week we had rain on five days, 2.1 inches falling. The weather has been cold and the days cloudy, so that the beets, instead of progressing, have really gone backward. The prospects at present are more favorable, as the sun has been shining all day, although it is still cold.

October 16.—The early part of the past week was rather more favorable for the ripening of the plants, as the days were clearer and the sun shining. However, before the moisture which fell the previous week had been absorbed it began to rain again, and during the past three days there has been a total rainfall of 0.49 inch. The beets are therefore making a second growth. The light frost the first part of the week did not seem to materially affect the ripening of the beets. Unless the crop ripens soon we shall have to cut the sample down to 25 feet, since the amount we have on hand will not permit the sending of any more samples from 50 feet.

October 24.—The weather during the first part of the past week continued to be unfavorable to ripening, and many of the plants have started a second growth of leaves. The weather for the past four days, however, has been such that this growth should be checked. The plants are looking very well and conditions are favorable.

October 29.—The weather of the past week has been much more favorable for the ripening of the beets. The days have been clear and cool, there being frost on five days and a temperature below freezing on four days. All the days have been full of sunshine.

November 6.—The weather of the past week on the whole has been rather more favorable for ripening the beets, and, while the majority of the days have been cloudy, the sun has shone about half the time. We have had two very heavy frosts and 0.19 inch of rainfall. The field as a whole looks well.

In the sample sent you on November 5, I also inclosed four beets of the character mentioned in my previous letter, i. e., having many roots. We find this type of beets more frequently in the part of the field to which it was necessary to transplant, but the beets sent with the sample are from a portion of the field to which no beets were transplanted.

We have followed the suggestion of Professor Huston and irrigated a portion of this field. The method of procedure was to apply each week enough water to make 1 inch when combined with the rainfall. This experiment was conducted on 10 rows of beets, 75 feet long, the last water being applied on August 3. It was necessary, in order to have the water applied equally, to ridge these 10 rows and, for purposes of comparison, 10 rows were also ridged to which no water was applied. It was a very noticeable fact that the beets which were irrigated wilted much more rapidly than those not so treated, and the irrigated section of the field is not reaching maturity as rapidly as the other portion.

November 14.—The weather of the past week has been more favorable for ripening the beets. Since sending the last sample we have had three cloudy days

and five clear days, with heavy frost on four days. The last three days have been cloudy and rainy, and yesterday about 1 inch of snow fell. The total rainfall for the week is 0.47 inch. To-day the weather has been slightly warmer. If the weather should continue favorable, the beets should reach a maximum in the next sample.

November 23.—Following the rain of the 17th the weather became suddenly much colder and the ground froze to about a depth of 3 inches on the 18th. The beets sampled on the 19th were frozen somewhat, but we tried to secure a sample that would be representative and not show the effects of the freezing. In estimating the yield of these plats I think the sample just sent may be taken as representative and that the yield per acre calculated upon this basis will not be far from right. The beets in all the plats from which samples have been sent you were planted in rows 22 inches apart.

ANALYTICAL DATA.

The following analytical data, determined both at the station and at Washington, show the results obtained on the irrigated and unirrigated plats, and the climatic conditions under which the experiment was made:

Agricultural and analytical data on beets grown at Lafayette, Ind., and forwarded to Washington, D. C., 1903.

Date of receiving sample at Washington.	Average weight after topping.	Estimated yield per acre.	Sugar in juice.	Sugar in beet.	Purity coefficient.
	Ounces.	*Tons.*	*Per cent.*	*Per cent.*	
September 28	11.5	----------	13.3	12.1	82.6
October 6	12.1	----------	15	13.9	83.3
October 13	14	----------	14.7	13.4	87
October 21	19.2	----------	13.3	12.5	83.4
October 30	15.3	----------	13.5	12.9	77.6
November 4	16.2	----------	13.1	12	75.3
November 11	13	----------	15.2	14.1	82.6
November 18	16.4	----------	15.5	14.3	80.7
November 25 [a]	16.4	----------	15	13.8	82
November 25 [b]	19.2	----------	14.3	13.2	80.3
November 25 [c]	19.2	----------	13.4	12.5	78.8
Average	14.9	[d] 8.9	14.3	13.2	81.6

[a] From same plat as previous samples.
[b] From plat for comparison with irrigated—excluded from average.
[c] From irrigated plat—excluded from average.
[d] Estimated from station data, capped beets.

Agricultural and analytical data on beets grown at Lafayette, Ind., determined at the Indiana Station, 1903.

Date of sampling.	Number of beets in 50 feet of row.	Total weight of beets.	Average weight of beets.	Estimated yield per acre.[a]	Lost in capping.	Net yield per acre.[a]	Sugar in juice.	Sugar in beet.[a]	Purity coefficient.
1903.		*Pounds.*	*Ounces.*	*Tons.*	*Per cent.*	*Tons.*	*Per cent.*	*Per cent.*	
September 25	47	44	15.1	9.3	34.4	6.1	12.8	11.8	83.6
October 1	62	52	13.3	11	12.2	9.7	14.6	13.4	85.4
October 8	48	47.8	15.8	10.1	22.4	7.8	14.2	13.1	86
October 16	44	55.3	20	11.8	5.7	11.1	13.5	12.4	85.7
October 23	41	51.1	20	10.8	18.6	8.8	13.5	12.4	82.8
October 29	39	47.1	19.3	10	18.1	8.2	14.6	13.4	88.6
November 5	55	46	13.3	9.8	18.4	8	14.7	13.5	86.1
November 13	52	65.5	20.1	13.4	21.4	10.5	14.7	13.5	81.5
November 19	46	59.8	20.7	12.8	20.1	10.2	14.7	13.5	84
Average	48	52.1	17.5	11	19	8.9	14.1	13	84.9

[a] Calculated at Washington, D. C.

Comparison of beets grown on irrigated and unirrigated plats as reported by the station, 1903.

Date of sampling.	Irrigated.		Unirrigated.		Irrigated.	Unirrigated.
	Sugar in juice.	Purity coefficient.	Sugar in juice.	Purity coefficient.	Yield per acre.	Yield per acre.
	Per cent.		*Per cent.*		*Tons.*	*Tons.*
September 14	12.1	85.2	11.4	87.7		
September 21	12.3	86	11.7	75.8		
October 1	13.9	85.3	14.5	85.3		
October 8	12.3	87.2	14.5	88.3		
October 23	12.1	80.5	13.4	85.4	6.5	8.3
October 29	14	89.2	14.4	92.9		
November 5	13	82.7	13.9	82.6	9.9	9.1
November 13	13.6	82.1	13.6	80.5	4.9	9.7
November 19	13.5	83.8	13.5	85.5	9.1	8.9
Average	12.9	84.9	13.4	85	7.6	9

Meteorological data for Lafayette, Ind., 1903.

Month.	Temperature.	Precipitation.	Clear days.	Cloudy days.
	° *F.*	*Inches.*		
May	65	2.71	9	21
June	65.8	2.37	11	17
July	74.2	2.68	16	13
Average and totals	68.3	7.76	36	51
August	71.6	5.05	12	16
September	65.4	1.96	17	12
October	53.4	2.58	17	10
Average and totals	63.5	9.59	46	38
General average and totals	65.9	17.35	82	89

Sunshine record for Indianapolis,[a] Ind., 1903.

Month.	Sunshine.		
	Actual.	Possible.	Percentage.
	Hours.	*Hours.*	
May	231.7	446.7	52
June	211.9	449	47
July	278.4	455.2	61
Average			53
August	224.5	425.2	53
September	255.1	373.6	68
October	224.4	344.9	65
Average			63
General average			58

[a] Fifty-nine miles southeast of Lafayette.

The very complete data from the Indiana Station show in a satisfactory way the general effect of the environment as a whole upon the character of the crop. The factors of the environment which most concern us in the present discussion are temperature, rainfall, altitude, and sunshine. The analytical data obtained at the station

agree very well with those obtained on the beets sent to Washington. The analyses made in the Bureau of Chemistry show a slightly higher content of sugar, but a somewhat lower coefficient of purity, than those obtained at Lafayette. From this and previous data received from the Indiana Station it appears that the purities obtained at that point are uniformly higher than those determined on the beets received from that station by this laboratory.

The beets at the Indiana Station were of a very satisfactory size, weighing on an average 14.9 ounces; but the yield was only 8.9 tons per acre. The data on the composition of the beet—i. e., 13.2 per cent of sugar in the beet and purity coefficient of 81.6—are unusually satisfactory. The influence of the various factors of the environment have been sufficiently described in the station report. It is evident that the principal determining factor, which shows its constant influence season after season, is the temperature; and the conditions which determine the temperature are largely latitude and altitude. In fact, it becomes more and more evident, as a study of these data proceeds, that the principal influence exerted by the other features of the environment is largely through the modifications which they produce in the temperature conditions. The hours of sunshine may perhaps be an exception, but even the good effects of long-continued sunshine may be counterbalanced by the tendency to raise the temperature during the growing season.

A comparison of the data obtained under irrigation with those secured under ordinary conditions is made possible by the figures furnished by the Indiana Station. The yield per acre on the irrigated plats was 7.6 tons and on the unirrigated 9 tons. This is rather a surprising contrast, showing the unexpected depressing influence of the irrigation upon the yield. The percentage of sugar in the juice was also lower in the beets from the irrigated than from the unirrigated plats, though the difference was only 0.5 per cent, while the purities were practically the same, being only 0.1 lower in the case of the samples from the irrigated plats. In general, it is seen that the practice of irrigation, at least under the other conditions which prevailed during the season, was injurious both to yield and quality.

THE IOWA STATION.

From the Iowa Station Mr. G. I. Christie, the soil assistant in charge of the experiment, reported, under date of July 20, as follows:

> The stand of beets is good, considering the season. The ground on which the beets are being grown was fall plowed and cultivated early in the spring, thereby placing it in good condition. At the time of sowing the ground was very loose, and to prevent sowing too deeply and to make a firm seed bed it was rolled.
>
> The seed was sown May 13, in rows 18 inches apart, at the rate of 22 pounds per acre. The seeding was followed by a light shower of rain, which caused

the seeds to germinate in a few days. When the beets were coming up there was a long period of wet weather, during which heavy rains fell, and the ground baked very hard, necessitating considerable work to save the crop. The beets were cultivated, bunched, and thinned when about 3 inches high. Since then they have been hoed twice, care being taken to remove all the weeds and any doubles which might be present. At the present time the beets are growing very rapidly and have attained good size.

With the samples of beets received on October 6 the following weight estimate was sent: The weight of the 25 beets sent is 45 pounds; the weight of the beets taken from 50 feet of a row is 65 pounds. On this basis the tonnage per acre equals 15.5 tons.

The data determined on the samples received at the Washington laboratory are given in the following table:

Agricultural and analytical data on beets grown at Ames, Iowa, and forwarded to Washington, D. C., 1903.

Date of receiving samples at Washington.	Average weight after topping.	Estimated yield per acre.	Sugar in juice.	Sugar in beet.	Purity coefficient.
	Ounces.	*Tons.*	*Per cent.*	*Per cent.*	
October 14	17.4	15.5	15.7	14.5	85.3
October 21	14.7	.....	15.1	15.7	77
October 30	7.6	.....	17.3	16.3	83.1
Average	13.2	15.5	16	15.5	81.8

The data from the Iowa Station are somewhat meager for this season. The average yield of beets per acre, according to the one estimation made, is 15.5 tons, and the average weight of the beets 13.2 ounces, showing that the beets were somewhat undergrown. For agricultural purposes—that is, for the proper compensation of the farmer—the beets should average over 1 pound in weight. The sugar content of the beets was very satisfactory, averaging 15.5 per cent, and the purity was reasonably high—i. e., 81.8.

The meteorological data show an average temperature for May, June, and July of 66.8°; for August, 69.4°; for September 60.5°, and for October, 51.6° F. The average temperature for the whole season, from May to October, inclusive, was 63.6° F. The precipitation was not very evenly distributed, being excessive in May and July and below the average in June, September, and October, the deficiency in the two latter months being distinctly favorable to the best development of the beet. On the other hand, the excessive precipitation in May must have influenced unfavorably the planting and germination of the seed, notwithstanding the efforts made by the agriculturist to prevent injury to the crop. The general average of the amount of sunshine is perhaps a little below the normal—i. e., 60 per cent—for the entire season. As has been shown, however, in a previous report,[a] the direct rays of the sun do not seem to be neces-

[a] U. S. Department of Agriculture, Bureau of Chemistry, Bul. No. 78, p. 42.

sary to the maximum development of sugar, as the luminous rays, which particularly influence growth, apparently pass with undiminished vigor through the clouds.

Meteorological data for Ames, Iowa, 1903.

Month.	Temperature.	Precipitation.	Clear days.	Cloudy days.
	°F.	Inches.		
May	62.3	9.46	15	9
June	64.8	1.97	14	4
July	73.4	4.77	20	3
Average and totals	66.8	16.20	49	16
August	69.4	3.70	17	4
September	60.5	1.46	16	6
October	51.6	1.07	23	3
Average and totals	60.5	6.23	56	13
General average and totals	63.6	22.43	105	29

Sunshine data for Des Moines, Iowa, 30 miles south of Ames, 1903.

Month.	Sunshine.		
	Actual.	Possible.	Percentage.
	Hours.	Hours.	
May	256.3	451.9	57
June	279.5	456.2	61
July	324.9	461.8	70
Average			63
August	249.9	429.4	58
September	192.8	374.5	51
October	220.6	342.5	64
Average			58
General average			60

THE KENTUCKY STATION.

The season of 1903 was very unfavorable and the beet crop suffered both in quantity and quality, as is shown by the analytical and agricultural data given in the table. The beets were grown, as usual, on a rich loamy soil that had been thoroughly plowed and subsoiled to a depth of 16 to 20 inches. Before planting, the earth was pulverized and put in perfect tilth by harrowing and rolling. On May 9 the seed was planted, and a good stand was obtained by May 16. On May 27 the plants were thinned to one or two plants every 3 inches and on June 6 to one plant every 9 inches. Three cultivations were given—on June 6 and 20 and July 6—by running a hand cultivator twice in the row and afterwards hoeing the plants. The ground was kept loose by repeated shallow cultivation. Twice during the growing season it was necessary to spray with arsenate of lead on account of the blister beetles.

The data obtained in regard to this season's work are as follows:

Agricultural and analytical data on beets, grown at Lexington, Ky., and forwarded to Washington, D. C., 1903.

Date of receiving samples at Washington.	Average weight after topping.	Estimated yield per acre.	Sugar in juice.	Sugar in beet.	Purity coefficient.
	Ounces.	*Tons.*[a]	*Per cent.*	*Per cent.*	
July 24	6.8	.....	11.1	10.2	69.9
August 7	12	.....	8.6	7.9	71.2
August 20	15.2	.....	10.1	9.3	74.3
August 29	10.4	.....	10.2	10	71.3
September 9	13.2	.....	11.4	10.5	73.5
September 28	13.9	.....	9.7	8.9	71.8
Averages	11.9	6.25	10.2	9.5	72

[a] Tonnage reported by station.

Meteorological data for Lexington, Ky., 1903.

Month.	Temperature.	Precipitation.	Sunshine.			Clear days.	Cloudy days.
			Actual.	Possible.	Percentage.		
	°*F.*	*Inches.*	*Hours.*	*Hours.*			
May	67.7	1.75	296.4	441.7	67	9	6
June	67.7	2.71	176.9	443.1	40	9	12
July	76.6	2.62	292.3	450.1	65	14	5
Averages and totals	70.7	7.08	.....	.....	57	32	23
August	74.4	1.49	264.7	422.1	63	13	6
September	69.8	.81	291	373	78	21	3
October	56.9	2.12	222.7	347.3	64	14	6
Averages and totals	67	4.42	.....	.....	68	48	15
General averages and totals	68.8	11.50	.....	.....	62	80	38

Although the conditions in Kentucky are described as distinctly unfavorable, the quality of the beets produced was not very greatly inferior to that of previous years. The yield per acre, however, was extremely low, being reported as 6.25 tons by the station. The sugar in the beet was equal to 9.5 per cent and the coefficient of purity was 72.

The meteorological data show that the total amount of precipitation from May to October, inclusive, was deficient, and only its very even distribution made it possible to grow a crop at all. The heaviest precipitation in any one month fell in June, viz, 2.71 inches, and the smallest in September, 0.81 inch. This small rainfall in September was distinctly favorable to the ripening of the beets. The average temperature for the three months ending with July was 70.7° F., the highest temperature in any one month was that for July, viz, 76.6° F., and the next highest for August, 74.4° F. The mean temperature for the months of June, July, and August, as will be seen, is above 70° F., a condition distinctly unfavorable to the development of a high sugar content. The percentage of sunshine was 62, not an excessively

high amount. The number of clear days was more than double that of the cloudy days. It is evident, therefore, that the growing beets were subjected to rather an excessive amount of direct sunshine as well as influenced by the high temperature. With a more abundant precipitation the temperature conditions would have been favorable to an excessively large crop, but of course with a diminishing content of sugar.

THE NEW YORK STATION AT GENEVA.

Owing to a severe drought it was impossible to prepare the ground intended for the beet work of 1903, so a change was made to a field which had been intended for alfalfa. The ground had been plowed from 11 to 12 inches deep just before sowing the beets, but not subsoiled.

The seed was sown on May 28 with a hand wheel seeder. Vegetation was retarded until June 15, as practically no rain fell from April 17 to June 11. A very even stand was secured, however. Cultivation was begun on July 6, and continued at intervals of from 10 to 12 days until the middle of August. The beets were thinned on July 8 to from 8 to 10 inches in the row. The only injury to the plants observed during their growth was a slight cutting of the leaves by hail on July 20, but the yield did not seem to be appreciably affected by this. At this time the beets were growing rapidly and had from 6 to 12 leaves to each plant. The crop was harvested on November 10, 1903.

In addition to the data given above the following agricultural and analytical data were reported by Mr. G. W. Churchill, and as no samples were forwarded to the Bureau of Chemistry these data constitute the entire record:

Agricultural and analytical data on beets grown at Geneva, N. Y., determined by the station at harvest time, 1903.

Weight of 50 beets.		Average weight capped.	Yield per acre.	Sugar in juice.	Sugar in beet.	Purity.
Topped.	Capped.					
Pounds. 45.5	*Pounds.* 36.25	*Ounces.* 11.6	*Tons.* 15.6	*Per cent.* 18.2	*Per cent.* 14.2	89.4

Two hundred analyses of individual beets which were selected by the appearance of the tops before digging gave an average percentage of sugar in the beet of 14.6. The difference of 4 per cent between the sugar in the juice and that in the beet (the latter having been determined, not calculated) remains unexplained.

The average data for the Geneva Station show a good yield per acre—15.6 tons—with, however, a somewhat too small average weight, viz, 11.6 ounces. The meteorological conditions during the early periods of growth were extremely unfavorable, and for the first

time during the series of observations the beets at Geneva failed to maintain their record of having the largest content of sugar. The purity of the juice, however, is extremely high. When the yield per acre and the purity of the juice are taken into consideration, it is seen that the Geneva crop is perhaps the best for sugar making of all the beets harvested during this year's experiment.

During May, when it was necessary to prepare the seed bed and plant, there was almost no rainfall at all. The entire area of the State of New York was subjected to a drought of unusual severity and prolongation. This month of excessive drought was followed by a very heavy rainfall during June, and again in August, while the amount of precipitation during the month of September fell to 1.3 inches. Again, in October, there was an excessive amount of precipitation, which must have interfered to a serious degree with the harvest and tended to induce a vigorous second growth. An inspection of the rainfall data shows the extremely irregular distribution of the precipitation. The temperature data show most favorable conditions for the growth of a beet high in sugar. During only one month was the average temperature above 70° F., and then it reached only 70.3° F. August was a remarkably cool month, being only slightly warmer than September. The range of the temperature during the whole season was extremely favorable to the development of a beet of high character, and doubtless served to develop the conditions favorable to a very high coefficient of purity of the juice.

Meteorological data for Geneva, N. Y., 1903.

[Furnished by station.]

Month.	Temperature.	Precipitation.
	° *F.*	*Inches.*
May	60.3	0.23
June	63.2	7.77
July	70.3	4.86
Average and total	64.6	12.86
August	65.5	7.21
September	64.4	1.30
October	52	4.19
Average and total	60.6	12.70
General average and total	62.6	25.56

THE NEW YORK STATION AT ITHACA.

The only report received from the Ithaca station in regard to the details of the season's work was written under date of July 27, by the assistant agronomist, Mr. J. W. Gilmore, as follows:

The seed was planted on May 12. The last rain which was of material benefit to planted seeds or growing plants fell March 31 and April 1, so that by the

time the beets were planted the ground was quite dry on and near the surface, consequently the seed only partially germinated. The drought continued until June 12, and since that time we have had copious rains, too much rain, in fact, to give the best conditions of growth. After the rains set in the remainder of the seed germinated, but fortunately there were enough plants of the first germination to make a good stand for 50-foot portions of the row. Up to July 20 the beets had been thinned, weeded, and cultivated four times, and they are growing well.

The analytical data determined at the Bureau of Chemistry on the samples received from Ithaca are given in the following table:

Agricultural and analytical data on beets, grown at Ithaca, N. Y., and forwarded to Washington, D. C., 1903.

Date of receiving samples at Washington.	Average weight after topping.	Estimated yield per acre.	Sugar in juice.	Sugar in beet.	Purity coefficient.
	Ounces.	*Tons.*	*Per cent.*	*Per cent.*	
October 9	7.6	.....	10.9	10.2	72.7
November 11	6.4	14.1	13.9	12.6	75.1
November 11[a]	4.1	.....	14.1	13.1	76.7
November 18	6.4	.....	13.9	12.8	76
November 23	5.7	12.6	13	12.1	74.3
Average	6	13.4	13.2	12.2	75

[a] Harvested October 19, 1903.

Although the station at Ithaca is not far distant from Geneva, quite a difference in the sugar content of the beets is noticed and also a marked difference in purity. The yield per acre at Ithaca was satisfactory. The same conditions of drought obtained during the early season as at the Geneva station. The amount of rainfall during May was only 0.3 inch, while for June and August it was excessive. October also was an extremely wet month, and consequently very unfavorable to the production of a beet of high character. The excessive rainfall in such cases tends to produce a second growth, which is largely at the expense of the accumulated sugar. During the season as a whole the cloudy days were in excess. The temperature at Ithaca was decidedly lower than at Geneva, July, the warmest month, having an average of only 67.4° F. August was a comparatively cool month, being only slightly warmer than September. In so far as the temperature conditions alone are concerned, they were decidedly favorable to the production of a beet with a high sugar content. No record of sunshine was kept at the Ithaca station, and the data for this factor of the environment are taken from the record of the Weather Bureau kept at Binghamton, N. Y., about 40 miles southeast of Ithaca.

Meteorological data for Ithaca, N. Y., 1903.

Month.	Temperature	Precipitation.	Clear days.	Cloudy days.
	°F.	Inches.		
May	57.6	0.30	16	6
June	60.8	5.67	2	19
July	67.4	2.64	7	18
Average and totals	61.9	8.61	25	43
August	63.6	7.15	3	17
September	61.6	1.21	11	9
October	50.6	5.69	3	18
Average and totals	58.6	14.05	17	44
General average and totals	60.2	22.66	42	89

Sunshine data for Binghamton, N. Y., 1903.

Month.	Sunshine.		
	Actual.	Possible.	Percentage.
	Hours.	Hours.	
May	338	451.9	75
June	129.5	456.2	28
July	247.2	461.8	54
Average			52
August	153.7	429.4	36
September	229	374.5	61
October	90	342.5	26
Average			41
General average			46

THE WISCONSIN STATION.

The first report on the experimental work at the Wisconsin Station was made by Mr. F. W. Woll, on July 20, as follows:

The land on which the beets are grown covers an area of 66 by 185 feet and adjoins the plat which was used for the sugar-beet experiments last year. The seed was sown on May 5, in rows 18 inches apart, 7 pounds of seed being used on the entire plat. The beets were up enough to show the rows on May 18, and were thinned June 3 and 4 to approximately 9 inches apart in the rows. The season has been very favorable to root crops up to this time, as we have had an abundance of rain and considerable cool weather. The stand on the plat is practically perfect, and the prospects for an excellent crop of beets are very good.

With the first sample of beets, on September 21, Mr. Woll reported on sugar content and yield as follows:

We analyzed the sample last week and found it rather low in sugar; so it is very likely that they have not improved much so far. With good clear weather for some time on they will, however, no doubt soon reach a fair sugar content, although, owing to attacks of rust on the beets from excess of moisture, they will not be apt to reach anything like the usual high percentage of sugar. The season this year has been extremely wet and cold, and all crops are more

or less behind. The weight of the 25 topped beets placed in the box is 27.55 pounds, and the calculated yield per acre, upon the basis of the beets dug in 50 feet of row, was 20.7 tons.

The final report from this station was received on November 2, after the harvest:

From the plat sowed 8.9 tons of beets were harvested. From the determination of the dirt in samples taken in different parts of the field, we found that the beets contained, on the average, about 4.5 per cent of dirt as weighed. The average per cent of sugar in the beet was 11.82, making the calculated yield of sugar per acre 3.1 tons.

As stated in my earlier letter, the past season was extremely wet and cold with us, and the beet field, being rather low, was submerged several times by water during the season after heavy rain storms. On account of the very wet season, rust attacked the beets and caused a large proportion of the old leaves to wither, thus reducing the sugar content of the beets, since the roots had to manufacture their sugar from a practically new set of leaves. Owing to the large yield of beets, however, which, as stated, amounted to over 26 tons to the acre, the yield of sugar was very satisfactory, viz, over 3 tons.

The analytical data determined at the Bureau of Chemistry on the samples received from Wisconsin are as follows:

Agricultural and analytical data on beets grown at Madison, Wis., and forwarded to Washington, D. C., 1903.

Date of receiving sample at Washington.	Average weight after topping.	Estimated yield per acre.	Sugar in juice.	Sugar in beet.	Purity coefficient.
	Ounces.	*Tons.*	*Per cent.*	*Per cent.*	
September 25	13.4	21.12	12.3	11.4	81.4
October 2	13.4	15.35	12.6	11.7	79.7
October 9	15.6	.....	12.7	11.8	80.4
October 17	16	22.18	11.4	10.8	75.5
October 30	16	.....	13	12.4	78.3
Average	14.9	19.55	12.4	11.6	79

The data from the Wisconsin Station show a large yield of beets per acre, viz, 19.6 tons. The content of sugar in the beets was exceptionally low for this locality, viz, 11.6 per cent, and the purity fell below the standard of 80, which is regarded as being the minimum for the economical production of sugar.

The meteorological data show that there was a reasonably even distribution of the rainfall. Rather too much rain fell during May, viz, 4.38 inches, which probably interfered to some extent with the preparation of the seed bed and planting. July and August had rather excessive amounts of precipitation, but inasmuch as these are the warmest months, producing the greatest loss of water by evaporation, heavy precipitation at this time is less apt to produce injury than at the beginning or end of the season. The only month in which there was a deficiency of rainfall was June, which had less rainfall

than is advantageous to rapid growth. The temperature conditions observed are distinctly favorable for the production of a beet of good sugar content, and in this case there appears to be a lack of correlation between low temperature and high content of sugar rather more pronounced than in any case yet observed. The average temperature of July, however, was 71.2° F., which is rather high for that locality, but the temperatures for June and August were not excessively high. The rainfall in October was greater than is compatible with the proper ripening of the beets, and the excessive precipitation in August, combined with the rather high amount in September, are doubtless the features in the environment which tended to inhibit the storing of sugar by stimulating continued growth.

Meteorological data for Madison, Wis., 1903.

Month.	Temperature.	Precipitation.	Clear days.	Cloudy days.
	°F.	Inches.		
May	59.8	4.38	10	14
June	63.6	1.39	8	10
July	71.2	7.17	11	16
Average and totals	64.9	12.94	29	40
August	66.2	6.95	5	13
September	60.5	3.51	11	8
October	50.4	2.18	16	10
Average and totals	59	12.64	32	31
General average and totals	62	25.58	61	71

EXPERIMENTS CONDUCTED IN IRRIGATED SECTIONS.

THE CALIFORNIA STATION.

The experiment for 1903 at Pomona, Cal., was a failure, owing to the following causes: The beets were planted on March 14 and appeared above the ground on March 26, but the stand was not a good one. From April 25 to May 5 the beets were attacked by worms and the larger part of the plants were destroyed. The beets were thinned on June 1, but it was so apparent that any results obtained would be misleading that the work was abandoned and no analyses or weighings were made.

THE COLORADO STATION.

At the Colorado Station fertilized and unfertilized plats were grown and samples of beets from each have been analyzed, though no special study of the effect of fertilizers has been included in this investigation as a whole. The descriptions of the soil and fertilizers will be found on page 30. The beets were planted on April 27, and

thinned and weeded from May 30 to June 4. Under date of June 11, Mr. Danielson reported as follows:

The beets are growing well, and the seed sent by you has proved superior in vitality to any planted on the farm. The field planted with that seed has a better stand, with stronger plants, than the fields where double the amount of seed of other varieties was used. On July 3 and 23 the beets were irrigated.

On December 19 a further report was sent on the results obtained on plats E and F, giving the following data:

Analytical and agricultural data on beets grown at Fort Collins, Colo., determined at the station.

[Determinations on 12 beets, November 7.]

Plat.	Yield per acre (tare subtracted).	Average weight of beets.	Average weight of tops.	Weight of tops per 100 pounds of beets.	Sugar in juice.	Sugar in beet.	Purity coefficient.
	Tons.[a]	*Pounds.*	*Pounds.*	*Pounds.*	*Per cent.*	*Per cent.*	
F {No. 6, fertilized	21.5	[b] 2.04	0.68	33	16.8	15.1	85
F {No. 9, complete fertilizer used	20.6	.....	.....	.....	17.9	16.1	87.9
E, not fertilized	19.8	1.67	.70	41	16.8	15.1	87.3

[a] Net weight, the tare having been subtracted.
[b] Average obtained on 352 beets was 1.25 pounds, tare subtracted.

A detailed report as to the stand and weight of beets is given below, and from these figures were calculated the tonnage as given, approximating closely the average figures reported by the station:

Stand of beets and weights on six successive dates.

FIELD E, UNFERTILIZED—50 FEET OF ROW.

	Sept. 26.	Oct. 6.	Oct. 10.	Oct. 17.	Oct. 23.	Nov. 3.
Number of beets in a row	54	58	49	60	66	58
Weight of 25 beets ..... pounds..	32	41	37.2	37	36	46
Weight of balance of row ..... do....	47.25	40	37.2	50	47	51
Total weight ..... do....	79.25	81	75	87	83	97
Estimated tonnage[a]	20.1	20.6	19.1	22.1	21.1	24.6

FIELD F, PLAT 6, FERTILIZED—50 FEET OF ROW.

Number of beets in a row	63	53	63	77	54	56
Weight of 25 beets ..... pounds..	38	36.5	45	29.5	40.7	44
Weight of balance of row ..... do....	40	39	47.5	54	40.25	47
Total weight ..... do....	78	75.5	92.5	83.5	84.95	91
Estimated tonnage[a]	20	18.8	23.5	21.2	21.6	23.1

[a] Average tonnage, 21.3.

The data determined on the samples received at the Washington laboratory are given in the following table:

Agricultural and analytical data on beets grown at Fort Collins, Colo., in 1903, as determined at Washington, D. C.

FIELD E, UNFERTILIZED.

Date of receiving sample at Washington.	Average weight after topping.	Estimated yield per acre.	Sugar in juice.	Sugar in beet.	Purity coefficient.
	Ounces.	*Tons.*	*Per cent.*	*Per cent.*	
October 3	17.2		14.8	13.8	79.1
October 14	21.7		16.4	15.3	81.5
October 17	16.6		16.1	15.6	79.7
October 30	16.6		16.4	14.4	80.4
November 6	17.2		18.6	16.2	87.3
November 14	19.8		16	15.1	77.6
Averages	18.2	21.3	16.4	15.1	80.9

FIELD F, PLAT 6, FERTILIZED.[a]

October 3	20.1		16	14.8	82
October 14	19.2		17.9	16.7	83.6
October 17	24.4		16.7	15.7	81.1
October 30	13.4		19.6	18.5	81.6
November 6	20.1		18	16.2	85.8
November 14	20.1		18.3	15.9	81.7
Averages	19.5	21.3	17.7	16.3	82.5

[a] Experimental plat.

The temperatures and precipitation recorded at Fort Collins are given in the following table, but no sunshine data are available for a nearer point than Cheyenne, Wyo.[a]

Meteorological data for Fort Collins, Colo., 1903.

Month.	Temperature.	Precipitation.
	°*F.*	*Inches.*
May	52.2	0.63
June	59.3	2.23
July	68.4	1.06
Average and total	60	3.92
August	67.6	.86
September	56.8	.87
October	49.4	1.48
Average and total	57.9	3.21
General average and total	59	7.13

The meteorological conditions in Colorado were satisfactory, only two irrigations, on July 3 and 23, being required for the growth of the crop. The great advantage which is secured through irrigation in regions where there is but little if any rainfall, lies in the fact that the period of growth and maturity is attended by the use of the proper amount of water. Thus the dangers which come

[a] See page 27.

through the retardation of growth by drouth during the summer months or by the induction of second growth by rainfall in September or October are avoided.

The temperature conditions at Fort Collins, as will be seen by consulting the table, are very favorable to the production of a beet of a high sugar content. The early months of the growing season were somewhat cold; and even in July, the warmest month, the temperature was only 68.4° F. August was almost as warm, while in October the temperature fell again to a low point, 49.4° F. The precipitation, for an arid region, was quite heavy, being almost sufficient in June for the needs of the crop, while almost half as much water as the crop needed fell in July. August and September were both quite dry, but in October there was considerable rainfall (1.48 inches), but not sufficient to induce any dangerous second growth. The total precipitation for the growing months was 7.13 inches, which is probably one-half or more of the total amount of water required.

The yield per acre is high and the percentage of sugar in the beet entirely satisfactory, viz, 16.3 per cent, with a purity of 82.5.

A comparative test of the effect of fertilization on the composition of the beet was carried on at the Colorado station during this season. The effect of the fertilizer on the yield of the beets was practically nil, the tonnage being only slightly greater on the fertilized plats according to the data reported by the station and exactly the same according to the other figures given. In fact, it is at once evident that a soil with a natural fertility capable of producing 21 tons per acre could not be much benefited by fertilization. There was a distinct effect of the fertilizer on the quality of the beets, an increase of 1.2 per cent in sugar content and 1.6 in the purity coefficient being secured. The data in this case show a tendency on the part of the fertilizer used to improve the quality of the beet and not to increase the production. The improvement of the quality, however, is not of a character sufficiently marked to warrant the conclusion that fertilizers can be used for this purpose economically.

THE OREGON STATION.

At Union, Oreg., where the experiment was conducted for the first time in 1903, the season was very dry, and at first there was little certainty of a crop, although the heat was not extreme. The plat was subirrigated from a near-by stream. The seed was sown on April 29, the soil having been plowed to a depth of 8 or 9 inches in the preceding fall, and the young plants were thinned on June 1. They were cultivated twice with hoes and three times with a horse cultivator. Later in the summer the conditions became more favorable and a good tonnage was obtained. On October 14 the prospects

for further development seemed so adverse that the beets were then harvested, while not yet mature. Attention had been paid to the matter of breeding, with the intention of obtaining uniformity in the sugar content. It was also hoped that by this means a strain could be secured that would be immune from aphis. Seed from 38 beets of known sugar content were planted, and in the course of the year 12 mother beets having the desired properties were designated for propagation. The results of this scheme can not fail to be interesting. The data on the beets, as determined at the Bureau of Chemistry in Washington, showed that the average weight per beet was 14 ounces, the estimated yield per acre 18 tons, the amount of sugar in the juice 19.8 per cent and in the beet 15.8 per cent, and the purity coefficient 88.3.

The data from Oregon are interesting in this respect, namely, that they belong to a region which has produced beets of phenomenal richness. Just what the conditions of the environment are in Oregon and Washington which have caused the growth of beets so rich in sugar it is difficult to determine. Probably many of the reported data concerning beets of this extraordinary quality are based on the analysis of abnormal samples or are obtained by methods not strictly controlled. Nevertheless, the fact remains and is confirmed by the data here submitted that the beets which are produced in this region are remarkably rich in sugar.

An inspection of the meteorological data reveals at least a presumptive reason for this condition. It is seen that the temperature conditions are remarkably uniform, varying but little during the whole season, from May to October, inclusive. The maximum average monthly temperature for the season was in August, and it is only 65.2° F. The minimum temperature occurred in October, when it fell to 49.6° F. The average temperature for June, July, and August was 4° below the standard of 70° F., which is regarded as the maximum compatible with the development of beets sufficiently rich in sugar to justify the establishment of factories. It appears, therefore, from a preliminary study of the environment of this region that the most important factor in the production of beets rich in sugar is found in the low temperature of the summer months.

The record of precipitation shows that the rainfall is not sufficient for the production of a crop, although the rate of evaporation must be low by reason of the low temperature. The beets were therefore subirrigated by the utilization of water from a near-by stream.

The number of clear days is remarkably high, showing an abundant supply of unobstructed sunlight. This is a condition which is not objectionable, provided the temperature remains low. The data regarding the growth of beets in these regions are still too fragmentary to permit of formulating definitely any statements respecting the influence of other features of the environment.

Meteorological data for Baker City,[a] Oreg., 1903.

Month.	Temperature.	Precipitation.	Clear days.	Cloudy days.
	° *F.*	*Inches.*		
May	51.2	0.49	10	10
June	64	1.29	7	12
July	62.8	.21	16	3
Average and totals	59.7	1.99	33	25
August	65.2	.87	23	3
September	54.3	1.06	13	11
October	49.6	1.14	14	11
Average and totals	57	3.07	50	25
General average and totals	58.4	5.06	83	50

[a] About 27 miles south of Union.

THE WYOMING STATION.

On July 27, Mr. Nelson, assistant in agronomy of the station at Laramie, reported as follows:

The plat is in good condition. The stand is good, and the plants had leaves about 6 inches long July 23, when examined. They had been properly thinned, hoed, and weeded, and were, on the whole, in as good a condition as could be expected.

The data determined at the Bureau of Chemistry show that the average weight of the beets after topping was 16 ounces, and the yield (reported by the station) 7 tons per acre; the percentage of sugar in the juice, 12.9; that in the beet, 11.8; and the purity coefficient, 69.4. The meteorological data are given in the following table:

Meteorological data for Laramie, Wyo., 1903.

Month.	Temperature.	Precipitation.	Sunshine.[a]			Clear days.	Cloudy days.
			Actual.	Possible.	Percentage.		
	° *F.*	*Inches.*	*Hours.*	*Hours.*			
May	43.9	1.63	268.4	449.1	60	15	5
June	53.9	1	251	451.9	56	17	2
July	62.6	1.31	291.8	458.6	64	18	4
Averages and totals	53.5	3.94	.....	.....	60	50	11
August	63.4	.88	288	427.4	67	22	0
September	51.2	2.39	250.4	374	67	17	5
October	43.4	.50	259.3	343.9	75	22	4
Averages and totals	52.7	3.77	.....	.....	70	61	9
General averages and totals	53.1	7.71	.....	.....	65	111	20

[a] Data for Cheyenne, about 45 miles southeast of Laramie.

The data from Wyoming are extremely fragmentary, and are only given tentatively as perhaps a foundation for future studies. Here we find a poor showing in respect of the richness of the beets, but the data are insufficient to make clear the principal factors of the environ-

ment which have been most active in depreciating the quality. It may be that in this case the temperature is too low for proper growth. It will be seen by a glance at the meteorological table that the warmest month is August and the average temperature is only 63.4° F. May was almost like a winter month, the temperature reaching only 43.9°, while June had an average temperature of only 53.9° F. These data show that there was scarcely heat sufficient to produce mature beets, and are quite in contrast with those for Oregon, where, especially at the beginning and end of the season, it was much warmer than in Wyoming.

Under date of June 16, 1905, in answer to a letter of inquiry sent by the author, Director Buffum made the following comments on beet growing in Wyoming:

Your statements about weather conditions are correct. Our seasons are short and cold and we do not get sufficient tonnage to make the beet crop profitable. Perhaps this can be overcome by breeding beets suitable for this soil and climate. You will find in past experiment station bulletins that we finished our beet investigations some years ago, coming to this conclusion. There are several sections of Wyoming at lower altitudes where sugar beets are a very satisfactory crop and where other conditions are suitable for sugar factories. Our beets are always raised under irrigation.

THE SOILS.

The following data descriptive of the soils on which the beets were grown in this year were received from the stations:

DESCRIPTIVE NOTES ON THE UNIRRIGATED SOILS.

AMES, IOWA.

The plat upon which the beets were grown in 1903 was in grass in 1897. It was plowed in the fall of that year and sown to winter wheat. Upon the removal of the wheat the soil was manured and sorghum was sown in 1899, followed by oats in 1900 and spring wheat in 1901. In 1902 a crop of sugar beets was harvested.

The soil is a black loam about 22 inches deep, underlain with a stiff yellow clay, which is full of carbonates. This soil is classified as a normal soil, requiring no special treatment.

LAFAYETTE, IND.

Prior to 1897 the crops grown were wheat, beets, and corn. In 1897 and 1898 the crop was beets. The history for the year 1899 is unknown. In 1900 the land was heavily manured and corn was grown. Soy beans were planted in 1901 and plowed under in the fall. In the year previous to the experiment the plat had been sowed with sugar

beets, but, owing to the failure of the crop, the land was summer fallowed. In March, 1903, the plat was plowed and harrowed, and reharrowed in May.

LEXINGTON, KY.

The beets were grown on the same rich, loamy soil on which this work has been conducted in previous years, known as "blue-grass" soil.

THE MICHIGAN STATION.

The following history of the plat used is given in connection with the soil analysis and the work of other years, though no beet analyses were obtained for 1903:

The plat selected for the experiment was a sandy loam, which had borne crops in years preceding as follows: In 1899, oats; in 1900, sugar beets; in 1901 it was seeded to clover without a nurse crop; in 1902, clover again. The ground had been subsoiled for the beets in 1900.

GENEVA, N. Y.

The field was sown to alfalfa in 1890 and this crop continued for five years. Crops were cut from three to four times each season for green forage or hay. In the fall of 1895 the field was plowed and sown in rye. In the spring of 1896, when rye was fully headed, it was plowed under and the ground was seeded again to alfalfa. This crop remained until the spring of 1901, when the alfalfa stubble was turned under and the field was planted in corn. This crop was followed in the spring of 1902 with barley. In the fall of 1902 the field was plowed and remained in the furrow until the following spring. The ground was plowed from 11 to 12 inches deep just before sowing the beets, but not subsoiled.

The soil was a clay loam varying from medium to quite heavy. The field from which these plats were taken is rolling, this portion broken up by a narrow "dip" extending nearly at right angles across the plats, running from north to south. A very slight loss in yield resulted from the washing by surface water after heavy showers on this portion of the plats. As the ground rises to the east of this "dip" it is heavier than that to the west.

ITHACA, N. Y.

At Ithaca the plat used was practically the same as that of the preceding year, and therefore the same data are applicable. The soil is a sandy loam of good depth and fertility.

BLACKSBURG, VA.

The following detailed comments on the soil sampling were sent by Mr. H. L. Price:

First opening.—A good average spot on the best part of the plat. Top soil 10 inches deep; line of demarcation between this and subsoil quite distinct. Top soil brownish black in color and contains considerable humus. Subsoil a sticky yellow clay, homogeneous, firm, and quite retentive of moisture. Contains no rock or pebbles. The total depth is 18 inches.

Second opening.—West end of plat. Top soil still a rich loam, practically the same as above, but a little lighter color; 9 inches deep. Line between top and subsoil clearly defined. Subsoil pale gray with ocherous tint; made up of silt and clay, free from pebbles.

This plat of land was planted to garden crops last year, and received frequent cultivation during the growing season. No manure or other fertilizer has been applied since the spring of 1902. In the spring of 1903 the ground was plowed very deep, but a subsoiler was not used.

MADISON, WIS.

The soil on which the beets were grown during 1903 is a clay loam with a heavy clay subsoil. A part of the field was in sugar beets in 1902 and in rape and peas in 1903. This field has been in cultivation for the past thirty years at least, and has been brought up to a high state of fertility through the application of barnyard manure and by pasturing sheep and swine in different seasons during the past twelve years or more.

DESCRIPTIVE NOTES ON IRRIGATED SOILS.

POMONA, CAL.

The beets were grown on a sandy soil, the analysis of which is given as a matter of record, though the crop for 1903 was a complete failure.

COLORADO STATION.

At Fort Collins, Colo., the beets were cultivated in fertilized and unfertilized plats. The history of these plats was given by Mr. A. H. Danielson, as follows:

Plat F (fertilized) had an application of land plaster three years ago. The crop in 1901 was beets; in 1902, grain; and in 1903, beets again. Plat E (unfertilized) had a heavy application of stable manure three years before the experiment. The crop for the year previous to the experiment was grain, and for the two years preceding that corn was grown.

The results of the experiment with fertilizers were embodied by Mr. Danielson in the following report:

The subject of sugar-beet growing is now greatly interesting to Colorado. It has increased until it is an important industry on a commercial basis. The

farmer's great interest lies in getting the most beets from his land. For this purpose he uses the powerful fertilizing effect of alfalfa, or barnyard manures, or when the supply of manures decreases he must in time turn his attention to commercial fertilizers, as older beet-raising sections have done. For this reason we have conducted some experiments, in order to be ready with information in time to be of use to the farmers in this section. Results as derived in humid climates are of little use to us, under arid conditions and irrigation. A little pioneer work will tell us in what direction to pursue experiments of like nature in the future. The past season's work in this line was carefully performed on three different fields. We believe the results give decided indications of what materials to use and what not to use. Our results are nearly ready to be published in detail should it be desirable to do so, but a few of the main conclusions from one season's work may here be briefly stated.

Nitrate of soda was the most effective among the commercial fertilizers. Five to six dollars' worth, or 150 pounds per acre of nitrate, increased the yield of beets over 4 tons per acre, worth over $20 at $5 per ton. Nitrate of soda used alone, however, lowered the sugar content and purity 1 to 2 points. Nitrate of soda used alone produced a better yield than 30 tons of cow manure per acre; 150 pounds of nitrate of soda and 15 tons of cow manure per acre produced a little better yield and more sugar per acre than 30 tons of cow manure per acre used alone. An excessive quantity of cow manure, or 60 tons per acre, made less yield and less sugar than 30 tons per acre. The shape of the beets was also poor with the larger quantity. Nitrate of soda with cow manure did not lower the purity as much as nitrate alone. One hundred and fifty pounds of nitrate of soda and 200 pounds of bone meal together made more sugar per acre, with higher purity, than nitrate alone. Phosphate fertilizers, as bone meal and basic slag, had little or no effect. So-called "complete fertilizers," with potash, had little or no effect. Complete fertilizers with the nitrogen from nitrates were more effective than the same with nitrogen from other sources. The plats were one-tenth acre in area; the yield ranging from 20.63 tons to 25.67 tons per acre in one field, and from 24.92 tons to 27.88 tons per acre in another.

The best results were obtained by mixing the fertilizers with the soil before planting the seed; fertilizers applied on top of the soil after the beets were up had no effect. In the case of nitrate of soda so applied the effect was positively injurious, decreasing the yields about 3 tons per acre and retarding the growth of the beets.

UNION, OREG.

At Union, Oreg., a plat was used which had been planted in sugar beets the preceding year. The soil was a dark loam, subirrigated from a near-by stream.

LOGAN, UTAH.

The plat used for the experiment in Utah was fertilized in January with well-rotted stable manure at the rate of 15 tons per acre, and was plowed 10 inches deep in April, about a week before the sowing.

ANALYSES OF SOILS.

In the following tables are given analyses of the soils used in these experiments:

Chemical analyses of soils used in the sugar-beet experiments of 1903.

[Percentages based on water-free soil.]

UNIRRIGATED SOILS.

Serial No.	Locality.	Description.	Insoluble.	Volatile.	Nitrogen (N).	Soluble in hydrochloric acid of 1.115 specific gravity.				
						Potash (K_2O).	Lime (CaO).	Magnesia (MgO).	Fe_2O_3, Al_2O_3, and Mn_3O_4.	Phosphoric acid (P_2O_5).
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
2133	Lafayette, Ind	Soil	82.74	6.86	0.208	0.38	0.43	0.43	8.43	0.11
2134	do	Subsoil	80.48	6.88	.163	.39	.54	.37	10.57	.07
2135	Ames, Iowa	Soil	82.06	9.29	.266	.27	.78	.22	7.08	.085
2136	do	Subsoil	85.63	5.99	.147	.18	.78	.30	7.66	.03
2147	Lexington, Ky	Soil	82.96	6.93	.238	.50	.54	.18	8.79	.51
2148	do	Subsoil	85.41	4.61	.127	.29	.45	.21	8.54	.11
2153	Agricultural College, Mich.	Soil	92.24	3.38	.098	.12	.36	.25	3.23	.08
2154	do	Subsoil	94.69	1.55	.014	.10	.36	.29	3.35	.03
2149	Geneva, N. Y	Soil	86.57	4.82	.147	.44	.51	.68	7.05	.09
2150	do	Subsoil	84.95	4.18	.070	.60	.51	.71	8.91	.08
2143	Blacksburg, Va	Soil	87.90	4.55	.112	.29	.16	.09	6.76	.13
2144	do	Subsoil	80.89	4.63	.021	.44	.22	.37	13.22	.04
2139	Madison, Wis	Soil	86.86	6.70	.182	.23	.58	.14	4.94	.14
2140	do	Subsoil	88.76	4.10	.088	.14	.47	.25	6.21	.11
2141	Washington, D. C	Soil	84.25	5.40	.140	.27	.45	.32	9.13	.10
2142	do	Subsoil	84.66	5.49	.128	.24	.42	.30	8.75	.08
		IRRIGATED SOILS.								
2145	Pomona, Cal	Soil	84.85	1.82	0.021	0.48	1.58	0.96	9.45	0.14
2146	do	Subsoil	85.05	2.25	.028	.47	1.60	.96	9.25	.15
2155	Fort Collins, Colo	Soil (F)	76.48	7.40	.175	.93	3.30	1.18	10.25	.16
2156	do	Subsoil (F)	73.21	10.94	.112	.60	4.38	1.37	9.09	.14
2157	do	Soil (E)	81.59	4.97	.140	.85	1.28	.67	9.92	.11
2158	do	Subsoil (E)	77.87	6.00	.105	1.06	.90	1.36	12.88	.09
2137	Union, Oreg	Soil	71.23	11.90	.343	.52	2.75	.48	12.97	.04
2138	do	Subsoil	73.66	9.10	.210	.41	2.14	.63	13.74	.07
2158	Laramie, Wyo	Soil	82.50	4.57	.112	.78	.75	.96	9.79	.10
2152	do	Subsoil	80.68	5.86	.070	.67	2.53	1.08	9.04	.10

Yield of beets and soil data, 1903.[a]

UNIRRIGATED SOILS.

Station.	Yield per acre.	Chemical analysis.		
		Potash.	Nitrogen.	Phosphoric acid.
	Tons.	*Per cent.*	*Per cent.*	*Per cent.*
Lexington, Ky	6.3	0.40	0.183	0.31
Lafayette, Ind	8.9	.38	.183	.09
Ithaca, N. Y	13.4	.44	.12	.14
Washington, D. C	14.6	.25	.133	.09
Ames, Iowa	15.6	.22	.206	.06
Geneva, N. Y	15.6	.52	.109	.085
Madison, Wis	19.6	.19	.135	.13
IRRIGATED SOILS.				
Union, Oreg	14	0.42	0.277	0.06
Laramie, Wyo	16	.73	.910	.10
Fort Collins, Colo	20.8	.67	.144	.15

[a] Averages of figures for soil and subsoil are given.

It is evident that no valuable comparison can be made of yield with the composition of the soil unless all other conditions of the environment are exactly the same. The analytical data, therefore, must be regarded rather as an indication of the potential capabilities of the soil than as an expression of their direct relation to the production of any particular crop.

In respect of potash soluble in hydrochloric acid (1.115 sp. gr.), it is seen that the soils from Geneva and Lexington contained the largest quantities, while those from Michigan and Wisconsin contained the smallest quantities. There is evidently a deficiency of potash in the soils last mentioned. Lime is an important factor in soils as affecting their physical texture and progress of nitrification. The extensive data which have been collected relative to the analysis of American soils show that lime is usually deficient in quantity. This accounts for the very common occurrence of acidity in our soils. Of the soils examined, those from Iowa, Wisconsin, Kentucky, and Geneva, N. Y., have the largest quantities of lime, while those from Virginia and Michigan have the smallest. None of the soils examined is remarkably rich in phosphoric acid except that from Lexington, Ky. The others only have the minimum quantity necessary for the production of a series of large crops, and it is probable that most of them would be benefited by an application of phosphatic material. As regards nitrogen, the soils, as a rule, have larger quantities than the subsoils, due, doubtless, to their larger content of organic matter. The samples from Indiana, Iowa, Kentucky, and Wisconsin have the largest quantities of nitrogen, while those from Michigan and Virginia have the smallest. The soil at Washington has almost the same quantity of nitrogen in the soil and subsoil, and this is explained by the fact that it was artificially formed, as already described.

The irrigated soils are all very rich in potash, and, since potash salts as a rule are quite soluble in water, it is evident that a soil which is infrequently leached by water would, other things being equal, have a larger quantity of potash than the soil from a wet region. The same remarks may be made as to the lime content of the irrigated soils, which is in some instances ten times as great as in the nonirrigated soils. The average amount of phosphoric acid in the irrigated soils is almost exactly the same as in the nonirrigated soils. This is partly due to the comparative insolubility of the phosphates of lime, alumina, and iron in water. The content of nitrogen in the irrigated soils varies greatly. There is scarcely any in the sample from California, while the soil from Oregon contains a very large quantity.

As has already been stated, it is not advisable to attempt to compare the fertility of soils as shown by chemical analysis with the magnitude of the crop, unless the other conditions of environment

are all strictly alike. The table, therefore, which gives the yield per acre, together with the content of principal plant foods of the soil, must not be too literally construed. Inasmuch as the roots of plants penetrate also into the subsoil, the data in this table are expressed as the average content of the ingredient mentioned in the soil and subsoil in each case. In general it may be said, as has been noticed in the previous experiments, that the soil has probably less to do with the chemical composition of the beet than any other factor of the environment. Under proper meteorological conditions, however, the soil is the chief factor in determining the magnitude of the crop.

SUMMARY OF DATA FOR 1903.

In the following tables are summarized the agricultural, chemical, meteorological, and geodetic data relating to the experimental work with sugar beets in 1903:

Summary of agricultural and analytical data, 1903.

WHERE IRRIGATION WAS NOT USED.

Station.	Mean weight of topped beets.	Estimated yield per acre.	Sugar in beet.	Coefficient of purity.
	Ounces.	*Tons.*	*Per cent.*	
Washington, D. C.	18.9	14.6	8.7	71.6
Lexington, Ky.	11.9	6.3	9.5	72
Madison, Wis.	14.9	19.6	11.6	79
Ithaca, N. Y.	6	13.4	12.2	75
Lafayette, Ind.	14.9	8.9	13.2	81.6
Geneva, N. Y.	11.6	15.6	14.2	89.4
Ames, Iowa	13.2	15.6	15.5	81.8

WHERE IRRIGATION WAS USED.

Laramie, Wyo.	16	----------	11.8	69.4
Fort Collins, Colo.	20.8	21.5	15.1	85
Union, Oreg.	14	18	15.8	88.3

Summary of meteorological data, May to October, 1903.

WHERE IRRIGATION WAS NOT USED.

Station.	Temperature.	Precipitation.	Clear days.	Cloudy days.	Sunshine.
	° *F.*	*Inches.*			*Per cent.*
Washington, D. C.	67.2	21.26	81	53	57
Lexington, Ky.	68.8	11.50	80	38	62
Madison, Wis.	62	25.58	61	71	----------
Ithaca, N. Y.	60.2	22.66	42	89	[a] 46
Lafayette, Ind.	65.9	17.35	82	89	[b] 58
Geneva, N. Y.	62.6	25.56	----------	----------	----------
Ames, Iowa	63.6	22.43	105	29	[c] 60

WHERE IRRIGATION WAS USED.

Laramie, Wyo.	53.1	7.71	111	20	65
Fort Collins, Colo.	59	7.13	----------	----------	[d]
Union, Oreg. [e]	58.4	5.06	83	50	----------

[a] Sunshine data for Binghamton, N. Y.
[b] Sunshine data for Indianapolis, Ind.
[c] Sunshine data for Des Moines, Iowa.
[d] See Laramie.
[e] Data for Baker City, Oreg.

Geodetic data.

WHERE IRRIGATION WAS NOT USED.

Station.	Average length of day.	Latitude.	Altitude.
	h. m.	° ′ ″	*Feet.*
Washington, D. C	14 23	38 53 23	87.5
Lexington, Ky	14 18	38 02 25	979
Madison, Wis	14 44	43 04 36	955
Ithaca, N. Y	14 41	42 27 00	810
Lafayette, Ind	14 30	40 23 00	542
Geneva, N. Y	14 44	42 53 00	453
Ames, Iowa	14 38	42 02 00	917

WHERE IRRIGATION WAS USED.

Laramie, Wyo			7,130.5
Fort Collins, Colo	14 32	40 35 00	4,994
Union, Oreg			2,789.6

CONCLUSIONS.

The general effect of the environment is represented by charts constructed on the same plan as that followed in the three previous reports. Chart No. 1 is a graphic illustration of the amount of sugar in the beet, the percentage of sunshine during the period of growth, the number of clear days in the month, and the latitude of the several stations. In general, it will be seen that the content of sugar in the beet varies with the latitude, the lowest sugar content in the lowest latitude, and vice versa. While, as is to be expected, there are variations in this curve, the general statement that the content of sugar rises as the latitude increases is again established. There is a less definite relation between the hours of sunshine and the sugar content of the beet. Inasmuch as it is generally conceded that the formation of sugar in the plant is a function which is largely influenced by light and can not be conducted without it, it seems only reasonable to suppose that the greater the quantity of light the greater the quantity of sugar developed. It is evident, therefore, that as the latitude increases the number of hours of light increase, thus giving the plant laboratory a longer working day. It has also been pointed out that light is more important than clear sunshine, since those radiations of the sun which are most active in stimulating the cellular activity of plants seem to suffer no marked diminution of power in passing through strata of aqueous vapor. The number of clear days varies greatly at the different stations; there was the lowest number at Ithaca, while Washington, Lexington, Lafayette, and Ames all had a very large number of clear days in proportion to the number of days in the month.

In chart No. 2 appear curves representing the percentage of sugar in the beet, the purity of the juice, the average monthly temperature

at the stations named, and the average length of day at these stations. This chart shows in a very decided manner the intimate relation between the percentage of sugar in the beet and the length of day. There are some apparent exceptions to this rule, but in general the agreement is close. The purity of the beets, as might be expected, bears a very close relation to the quantity of sugar in the beet. The curve representing the temperature, as in former investigations, shows that as a rule the temperature varies inversely as the sugar content of the beets, being highest when the sugar is lowest and lowest where the sugar is highest. The irregularities of this curve are more pronounced in the present chart than in any of those appearing in previous reports during which the investigation has been conducted.

Chart No. 3 is a graphic comparison of the percentage of sugar in the beet, the total rainfall during the season at the various stations, together with its distribution by months, and the altitude of the stations. There is a general agreement shown between the percentage of sugar in the beet and the altitude of the station, but this agreement is not uniform, and it is evident that the only effect of the altitude will be found in diminishing the temperature and that otherwise it can not have any possible effect upon the composition of the beet. There is an apparent relation between the amount of rainfall and the sugar content, the curves rising together, but this may be regarded as an indication of no value, but rather as accidental, and, moreover, there are wide and violent variations from the general agreement. The distribution of the rainfall appears to have had no direct effect upon the content of sugar in the beet. It is evident, however, that there might be such a distribution of the rainfall as to influence unfavorably the sugar content, and this has been pointed out in the discussion of the data of the various stations. There would be undoubtedly a tendency of the rainfall to diminish the sugar content if it should be so distributed as to restrain the normal growth of the beet during the growing period, especially in August, or to unduly stimulate it by excessive rainfall during the period when ripening would naturally take place, as in September and October. A number of instances of this kind have been already pointed out.

The data for the year 1903 are less decisive and less complete than for any other year, but are placed on record as of comparative value in connection with those secured during the other years of the cooperative experiment.

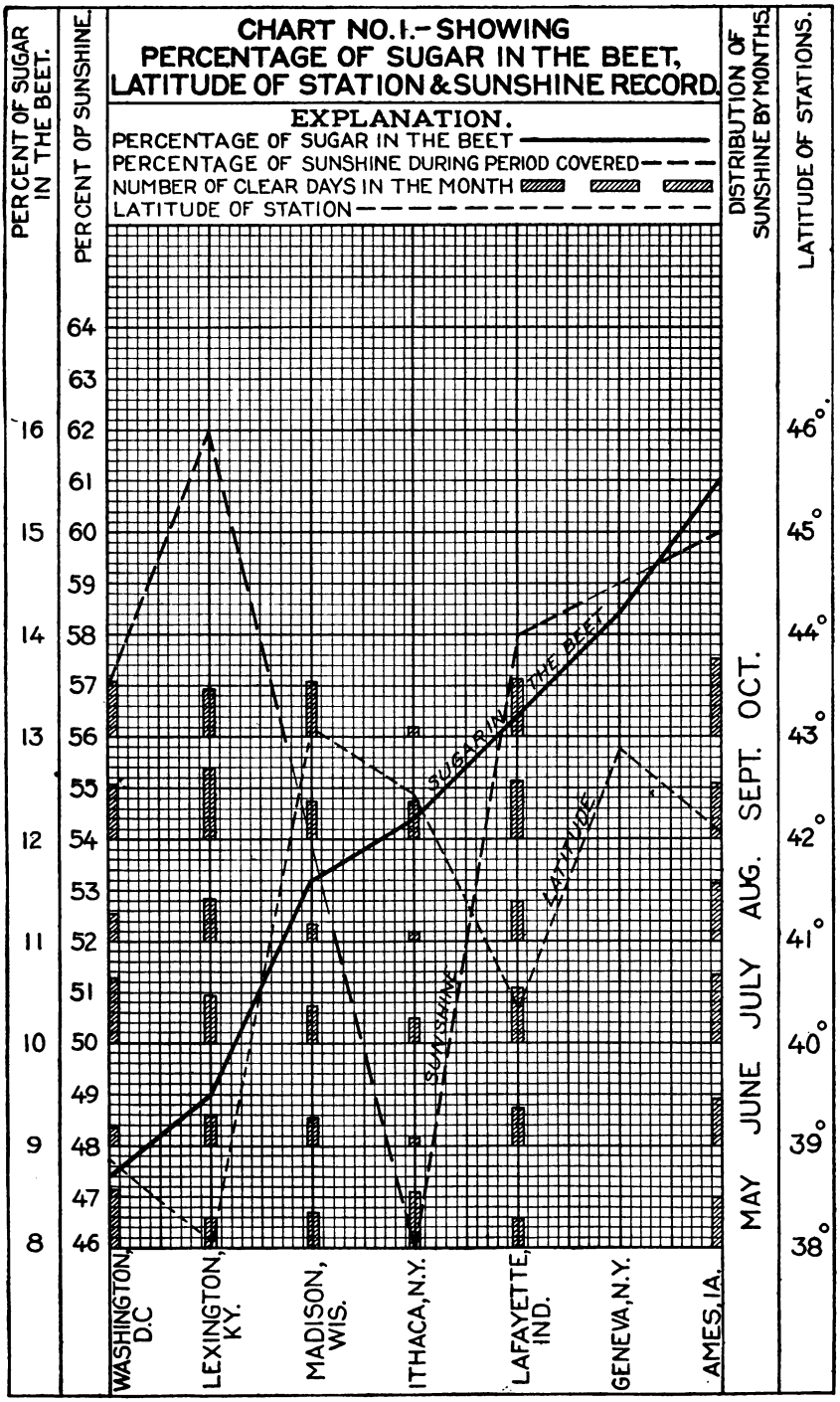


FIG. 1.—Sugar content of the beet as influenced by the amount and distribution of sunshine and the latitude of the station.

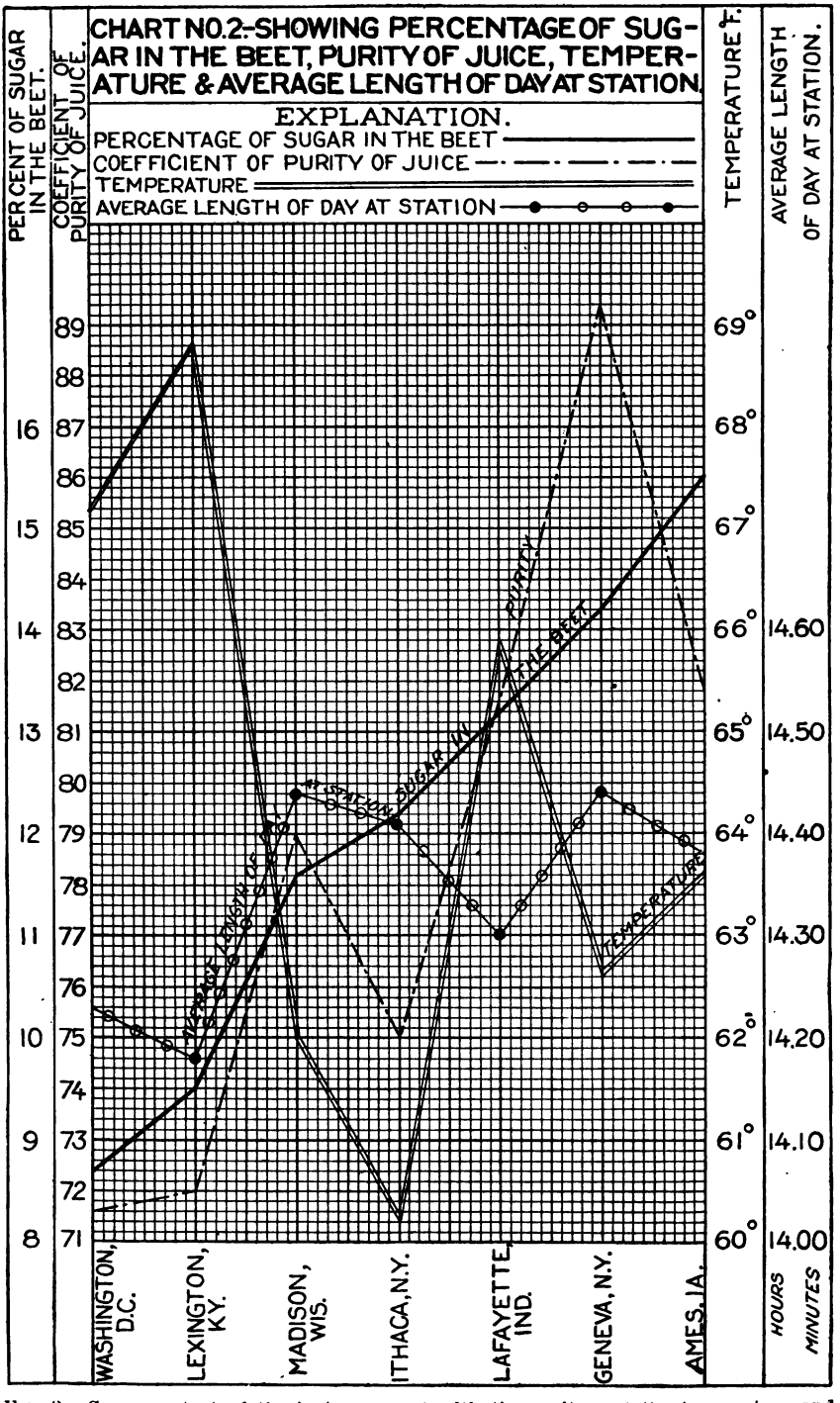


FIG. 2.—Sugar content of the beet compared with the purity and the temperature and average length of day at the various stations.

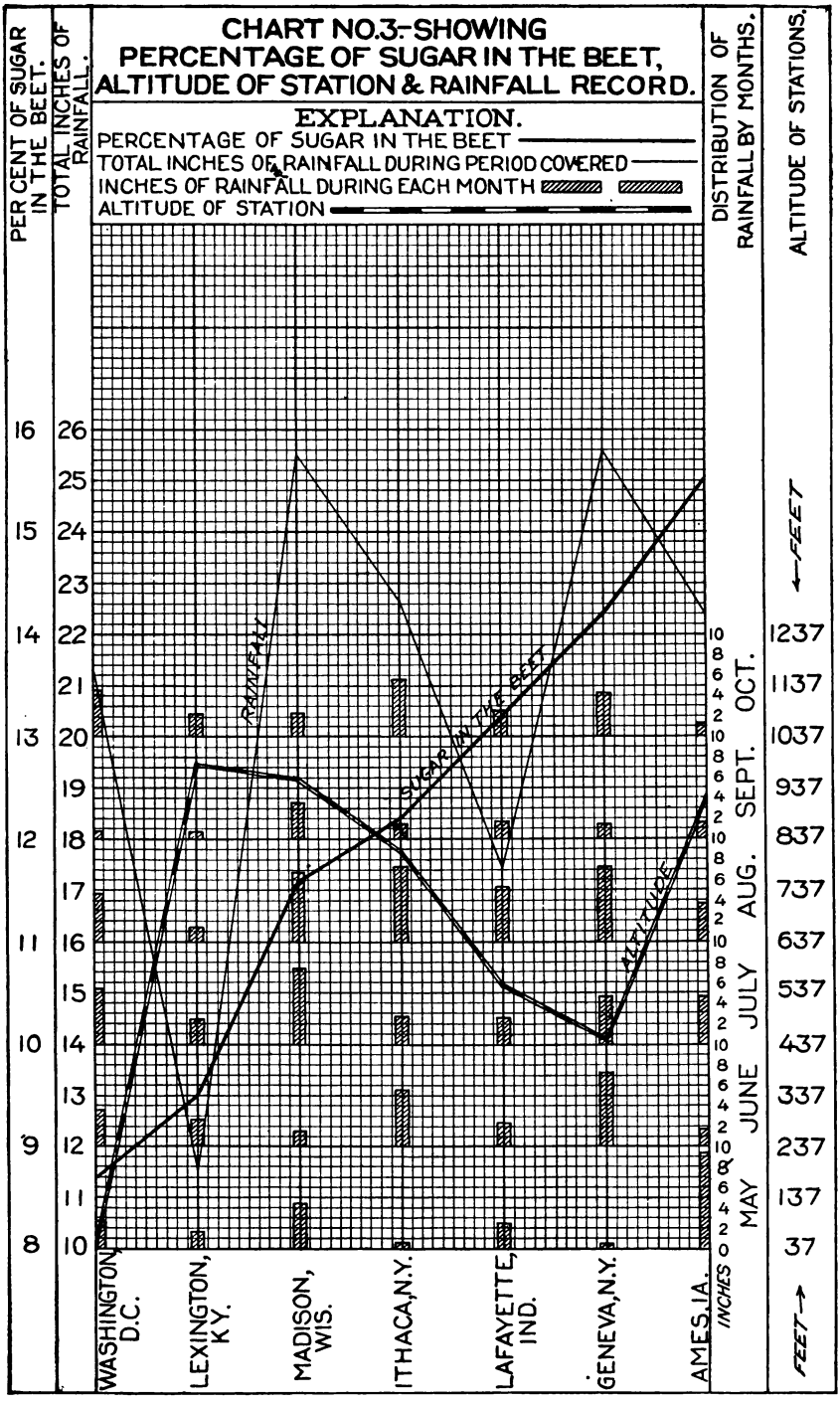
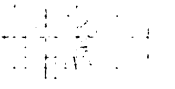


FIG. 3.—Sugar content of the beet as influenced by the amount and distribution of rainfall and the altitude of the station.



U. S. DEPARTMENT OF AGRICULTURE.

BUREAU OF CHEMISTRY—BULLETIN No. 96.

H. W. WILEY, Chief.

INFLUENCE OF ENVIRONMENT ON THE COMPOSITION OF THE SUGAR BEET, 1904,

TOGETHER WITH

A SUMMARY OF THE FIVE-YEAR INVESTIGATION.

BY

HARVEY W. WILEY,
Chief of Bureau,

IN COLLABORATION WITH THE AGRICULTURAL EXPERIMENT STATIONS OF CALIFORNIA, COLORADO, INDIANA, IOWA, KENTUCKY, MICHIGAN, NEW YORK (GENEVA AND ITHACA), NORTH CAROLINA, UTAH, VIRGINIA, AND WISCONSIN.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1905.

LETTER OF TRANSMITTAL.

U. S. DEPARTMENT OF AGRICULTURE,
BUREAU OF CHEMISTRY,
Washington, D. C., June 1, 1905.

SIR: I beg to submit for your approval manuscript and graphic charts embodying the results of the cooperative work conducted by this Bureau on the effect of environment on the composition of the sugar beet during 1904, together with a summary of the results obtained during the five years that this investigation has been making, the research being now completed. I recommend the publication of this report as Bulletin No. 96 of the Bureau of Chemistry.

The analytical work done in the Bureau on the beets was performed by Messrs. C. G. Church and Martin Boyle; that on the soils by Messrs. F. P. Veitch and T. C. Trescot. The cooperation of the various stations which took part in the experiment is deserving of recognition, but especially is the work of those stations appreciated which suffered no interruption throughout the five years, viz, Kentucky, Wisconsin, New York (Geneva and Ithaca), and Indiana, one year's data being missing in the case of the last-named station on account of failure of the crop. The Weather Bureau, the United States Coast and Geodetic Survey, and the Naval Observatory have also furnished certain data.

Respectfully,

H. W. WILEY, *Chief.*

Hon. JAMES WILSON,
Secretary of Agriculture.

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INFLUENCE OF ENVIRONMENT ON THE COMPOSITION OF THE SUGAR BEET, 1904.

ORGANIZATION OF COOPERATIVE WORK.

In organizing the work for this year, the last of the present investigation, every effort was made to send explicit instructions and to insure the receipt of complete data. These instructions read as follows:

INSTRUCTIONS FOR SUGAR-BEET WORK, 1904.

For the purpose of the Bureau of Chemistry a square plat of one-eighth of an acre will be sufficient. It should be seeded heavily to insure a good stand and enough seed reserved for replanting if the first planting should not germinate.

PREPARATION AND SAMPLING OF SOIL.

The soil should have been plowed to the depth of 8 or 9 inches and subsoiled to at least 6 inches more, making a seed bed of at least 15 inches in depth. If the character of the soil warrants it, a deeper plowing, even to 10 or 11 inches, is advisable. The surface of the soil should be reduced to a fine tilth and well harrowed and stirred immediately before planting, to stop all growth of weeds that may have started.

Representative samples of the soil and of the subsoil from the plats on which these beets are grown are desired for chemical and physical analysis. After securing such a sample reduce it in size by quartering or otherwise to obtain final samples weighing not more than 4 pounds each. Place these in *paper bags* and then in the cloth bags sent herewith, using addressed marked tags, also forwarded. Please inclose a slip giving the kind of soil, date of sampling, etc., and send as complete a history of the plat as possible.

CULTURAL DATA.

The rows should be 18 inches apart and the seed planted at the rate of 25 pounds per acre. If the soil be moist, the seed should be covered to a depth of 0.5 to 1 inch. If the weather be dry, a slightly deeper planting is advisable.

As soon as the plants are vigorously growing they should be separated into clumps by a hoe 6 inches in width, leaving the length of 3 inches of beets in each bunch. When the beets have a vigorous growth and begin to form the fourth leaf, they should be thinned to about one plant in each 9 inches. If the soil be very fertile, the beets may be left closer together. Ordinary surface cultivation is all that is required, being careful not to cover up the beets at the first cultivation.

SAMPLING BEETS.

One month prior to the usual time of harvesting beets in your locality begin harvesting beets from the experimental plat. Harvest every beet in 50 feet of an inside row. Remove the leaves, clean the beets, and weigh them. Select 25 average beets, weigh them, and,

without topping, forward them to this Bureau by express, collect, inclosing description tag filled out. *Give all weights* and your estimate of the tonnage based upon beets from 50 feet of row. Repeat sampling once each week until frost prevents further operations or the beets begin to deteriorate.

FURTHER REPORTS.

More detailed reports will be gladly received for incorporation in the bulletin. If practicable, make check analyses from time to time for comparison with the analytical work done at this Bureau. While the Weather Bureau reports will be used for meteorological data, any additional observations, comments on special features of the season, etc., will be of service.

STATIONS COOPERATING IN 1904.

The following stations agreed to cooperate in the work: California, Colorado, Indiana, Kentucky, Michigan, New York (Geneva and Ithaca), North Carolina, Virginia, and Wisconsin. These experiments, together with those conducted at the Bureau of Chemistry on the Potomac flats, gave a total of eleven cooperating stations.

The seed furnished for this experiment by the botanist in charge of seed and plant introduction and distribution, Bureau of Plant Industry, was grown by E. H. Morrison, at Fairfield, Wash., from Kleinwanzlebener mother beets of exceptionally high sugar content and purity. The seed was of the 1904 crop and germinated 169.5 sprouts per 100 seed balls.

EXPERIMENTS CONDUCTED IN HUMID REGIONS.

POTOMAC FLATS, WASHINGTON, D. C.

As has been the practice at Washington, the beets were planted on four successive dates one week apart, and, the planting on May 20 proving the most successful, the data for that plat are used in the discussion and on the graphic charts. The yield per acre of 14.9 tons is slightly below the average of previous years, but the beet is very superior in quality, a result predicted before the analyses were made by reason of the character of the season. The content of sugar in the beet is 11.4, about 3 per cent higher than in previous years, and the purity is correspondingly higher, viz, 76.1, an increase of about 6 points. An explanation of this decided improvement in the quality of the beet is to be found in the moderate and evenly distributed temperature occurring in conjunction with an ideal distribution of the rainfall. There was no month of an unusually high temperature, the average for the season being 67.3° F., and for the three growing months, June, July, and August, 72.6°, one-tenth of a degree warmer for the season than in 1903, however, in which year no such improvement was seen. The distribution of the rainfall, therefore, must have played an important part in the change in the

beet. There was a sufficient precipitation in May to properly germinate the seed; June had a rainfall of 5.49 inches, an amount favorable to rapid growth; in July, the warmest month, the heaviest precipitation is recorded, viz, 6.25 inches; and during September and October it diminished decidedly, affording excellent conditions for the ripening and harvesting of the beets and precluding the possibility of any second growth at the expense of the sugar content. It is seen that these conditions leave nothing to be desired in regard to the proper growth and maturity of the beet, and they doubtless explain, in conjunction with the moderate temperature, the superiority of the beets over those of previous years. The season of 1903 had practically the same temperature, but did not have the ideal distribution of rainfall which characterized the season of 1904.

Agricultural and analytical data for beets grown on the Potomac flats, District of Columbia, in 1904, showing averages for different dates of planting.

Plat No.	Date of planting.	No. of beets in 50 feet of row.	Weight after topping.		Estimated yield per acre.	Sugar in juice.	Sugar in beet.	Purity coefficient.
			Total.	Average.				
	1904.		*Pounds.*	*Ounces.*	*Tons.*	*Per cent.*	*Per cent.*	
1	May 6	68	46	10.5	11.7	11.7	10.9	72.1
2	May 13	57	50	14.1	12.8	12.1	11.4	75.7
3	May 20[a]	70	58	12.5	14.9	12.2	11.4	76.1
4	May 27	55	35	10.5	9.1	12.5	11.7	75.5

[a] Data for May 20 platted.

Meteorological data for Washington, D. C., 1904.

Month.	Mean temperature.	Precipitation.	Sunshine.			Clear days.	Cloudy days.
			Actual.	Possible.	Percentage.		
	° F.	*Inches.*	*Hours.*	*Hours.*	*Per cent.*		
May	65.0	2.64	337.0	443.8	76	17	2
June	71.0	5.49	270.9	445.9	61	12	8
July	74.4	6.25	262.3	453.0	58	9	7
Averages and totals	70.1	14.38	.....	.....	65	38	17
August	72.3	2.44	208.9	423.2	49	10	10
September	67.4	1.71	208.3	373.4	56	10	5
October	54.1	.57	255.1	346.0	74	21	4
Averages and totals	64.6	4.72	.....	.....	59	41	19
General averages and sum totals	67.3	19.10	.....	.....	62	79	36

THE KENTUCKY STATION.

The sugar beets were grown on a rich loamy soil which had been thoroughly plowed and subsoiled to a depth of 16 to 20 inches. Before planting the seed, on April 22, the earth was thoroughly pulverized and put in perfect tilth by repeated harrowing and rolling. The seed was planted in 18-inch rows with a hand drill. A good stand was obtained, the beets coming up about May 5. When the

plants had four or five leaves, on June 1, they were thinned, leaving one or two plants every 3 inches. On the second date of thinning, June 13, they were thinned to one plant in every 9 inches. Three cultivations were given—on June 13, 21, and 27, the ground being kept free from weeds, and loose. The cultivation consisted of running a hand cultivator twice in the row and afterwards hoeing the plants. It was necessary to spray with arsenate of lead because of the presence of blister beetles.

Only two samples of beets were received for analysis, the data for which and the meteorological data for the growing season at Lexington are given in the following tables:

Agricultural and analytical data on beets grown at Lexington, Ky., and forwarded to Washington, D. C., for analysis, 1904.

Date of receiving samples at Washington.	Average weight after topping.	Estimated yield per acre.	Sugar in juice.	Sugar in beet.	Purity coefficient.
	Ounces.	*Tons.*	*Per cent.*	*Per cent.*	
August 1	10.7	.....	12.2	11.30	70.8
August 1	9.0	.....	12.8	11.65	74.0
Average	9.8	[a] 8.9	12.5	11.48	72.4

[a] Reported by stations.

Meteorological data for Lexington, Ky., 1904.

Month.	Mean temperature.	Precipitation.	Sunshine.			Clear days.	Cloudy days.
			Actual.	Possible.	Percentage.		
	° *F.*	*Inches.*	*Hours.*	*Hours.*	*Per cent.*		
May	63.8	2.60	259.3	441.7	67	15	9
June	71.8	2.51	302.8	443.1	68	13	3
July	73.9	3.13	325.1	450.1	72	17	3
Averages and totals	69.8	8.24	.....	.....	69	45	15
August	74.2	2.44	310.4	422.1	74	15	4
September	69.4	1.71	280.3	373.0	75	12	5
October	57.0	.57	294.0	347.3	85	22	0
Averages and totals	66.9	4.72	.....	.....	78	49	9
General averages and sum totals	68.4	12.96	.....	.....	73	94	24

The estimated yield per acre at Lexington was quite low, namely, 8.9 tons. The percentage of sugar in the beet was considerably higher than in former years, reaching 11.5 per cent. The purity, however, was exceptionally low, being represented by the coefficient 72.4. The mean temperature from May to July inclusive was 69.8° F. and presents a very fair range for the three months; the average temperature from August to October was 66.9°, that of the three growing months, June to August, 73.3°. The average for the six months was 68.4°, a temperature favorable to the production of a beet with a reasonably high percentage of sugar. The rainfall,

although slightly deficient, was very evenly distributed, the smallest precipitation occurring in September and October, when it is least needed, and being therefore favorable to the production of a beet with a reasonably high percentage of sugar. The ratio of clear days to cloudy ones shows a remarkable freedom from heavy clouds. The number of clear days is almost four times that of the cloudy days reported. The percentage of sunshine is also very high. In spite of the small percentage of cloudy weather, the temperature was below normal. All conditions, therefore, combine, in so far as the meteorological data are concerned, to produce a crop of beets remarkably rich in sugar for that latitude and such a crop was actually produced.

THE MICHIGAN STATION.

The beets were planted at the Michigan Station on May 11, thinned on June 17, and sampled on October 15, 22, and 28. The weather was dry from July 8 to August 25, but otherwise the season was favorable. The following data were obtained on the three samples analyzed:

Agricultural and analytical data on beets grown at Agricultural College, Mich., and forwarded to Washington, D. C., for analysis, 1904.

Date of receiving sample at Washington.	Average weight after topping.	Estimated yield per acre.	Sugar in juice.	Sugar in beet.	Purity coefficient.
	Ounces.	*Tons.*	*Per cent.*	*Per cent.*	
October 24	9.0	12.8	16.9	15.6	84.5
October 28	8.6	14.1	17.2	15.8	89.5
November 5	12.2	18.6	16.3	15.1	84.0
Averages	9.9	15.2	16.8	15.5	86.0

Agricultural data determined at the Michigan Station, 1904.

Date of sampling.	Beets in 50 feet of row.		Estimated yield per acre.
	Number	Total weight.	
		Pounds.	*Tons.*
October 15	69	50.0	14.5
October 22	69	55.0	16.0
October 28	55	57.5	.....
Averages	64	54.1	15.3

The yield per acre at the Michigan Station is very satisfactory, viz, 15.2 tons, notwithstanding the fact that the size of the beets is considerably less than a pound, averaging 9.9 ounces. The tonnage, high sugar content, 15.5 per cent, and high purity, 86, combine to make the production of the crop remunerative. The data on the yield as obtained at the Michigan Station are almost identical with the figures obtained at Washington.

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The average temperature from May to July was 64.1° F.; from August to October, 58.8°; from June to August, 66.9°; and the average temperature of the six months was 61.5°. The warmest month was July, with an average temperature of 69.2°. August was much cooler, averaging 65.9°. The rainfall also was well distributed, with the exception of July, during which month the precipitation was below the normal. Both September and October, especially the former, show a precipitation which would have a tendency to continue growth and to stimulate it. However, it was not an excessive precipitation, and probably did not interfere greatly with the ripening of the beet. The other meteorological data are taken from the station at Detroit, and indicate an excess of cloudy weather. Upon the whole, the meteorological data may be considered favorable to the production of a beet of high quality.

Meteorological data for Agricultural College, Mich., 1904.

Month.	Mean temperature.	Precipitation.	Sunshine.[a]			Clear days.[a]	Cloudy days.[a]
			Actual.	Possible.	Percentage.		
	°F.	*Inches.*	*Hours.*	*Hours.*	*Per cent.*		
May	57.4	2.40	252.0	451.9	56	7	14
June	65.6	2.49	237.5	456.2	52	6	15
July	69.2	1.97	293.5	461.8	64	7	9
Averages and totals	64.1	6.86	.....	.....	57	20	38
August	65.9	3.26	307.1	429.4	72	16	4
September	[b] 62.0	2.35	227.0	374.5	61	8	7
October	48.6	1.90	167.2	342.5	49	8	14
Averages and totals	58.8	7.51	.....	.....	61	32	25
General averages and sum totals	61.5	14.37	.....	.....	59	52	63

[a] Data for Detroit, Mich., about 75 miles southeast of Agricultural College, the nearest point at which the sunshine data were observed.

[b] Ten days missing from record.

THE INDIANA STATION.

A very complete report was received from Mr. W. J. Jones, jr., of the Indiana Station, including a comparison of results obtained on fertilized and unfertilized plats. The unfertilized plat, No. 2, was reported as the one especially devoted to the cooperative work, and the average data obtained from the two unfertilized plats are used in the graphic charts. The following cultural data were reported:

CULTURAL DATA.

The dimensions of the plat were 98 by 248 feet, and the area 0.56 acre.

April 29.—Ground plowed to depth of 9 inches and harrowed. Soil and subsoil sampled and samples forwarded to Washington.

May 7.—Soil harrowed both ways and broken with clod crusher. Beets planted; rows 18 inches apart. Day warm and partly cloudy. Soil in excellent condition; temperature of soil 66° F.

May 16.—Beets coming through. Stand apparently good.

May 23.—Beets all up. Stand thick with a few barren spots. Owing to low temperature and cold rains beets have made but little progress since coming up. Seed seems to have all germinated.

May 25.—Beets very weedy. Cultivated with hand cultivator.

May 27.—Beets doing nicely. Fourth leaf appearing, but plants too small to thin. Rows at edge of field are being attacked by cutworms

June 2.—Ground full of cutworms which have destroyed many plants. Transplanted beets to all spaces of 9 inches or over. Day partly cloudy, temperature moderate, soil hard but moist All conditions favorable for successful transplanting. Transplanted only healthy plants in bunches; used transplanter and making deep holes. Thinned plants to clumps of 3 inches with 6-inch spaces between clumps. Stand excellent All weeds removed with hoe and soil loosened around beets.

June 4.—Weeding of plants finished. Transplanted plants doing nicely, and entire field making great progress.

June 9.—Plants in good condition, but show need of rain. Cutworms still working.

June 11.—Need of rain still apparent. Field cultivated and free from weeds.

June 14.—Plants making rapid growth; thinned to 9 inches, and weeds removed from between plants.

June 20.—Plants growing rapidly. Stand excellent, but a little irregular as to size of plants. Plants have 10 leaves. Soil in excellent condition. Cucumber bugs in field. No loss from transplanting.

June 22.—Beets cultivated.

June 27.—Plants in excellent condition, and have made rapid progress since June 22. Plants practically the same size in all parts of field. Stand perfect. Field clean and soil in fine condition. Plants large enough to shade the ground. Cucumber bugs have done little damage.

June 30.—Part of field hoed. Hail storm cut leaves badly, but the damage is not serious.

July 2.—Balance of field hoed and weeds removed from between plants in part of field.

July 9.—Weeding of plants concluded. Plants in fine condition, and leaves broken by hail are still large enough to shade ground.

July 17.—Condition of plants very satisfactory. Ground baking and needs cultivation.

July 19.—Beets cultivated.

July 25.—Field in fine condition and beets making good growth; foliage much larger. Rain would be beneficial.

July 30.—Beets showing effect of drought and wilting badly; growth good, but the need of rain very apparent.

August 3.—Effect of drought very marked; leaves badly wilted and turning yellow.

August 7.—Plants making some progress, but drought is delaying growth and leaves are gradually falling off. Huston's Evil Eye making its appearance.

August 14.—Ground so dry it has begun to crack. Plants making but little progress.

August 21.—Plants show little change in condition from report of preceding week.

August 23.—Field hoed and very clean.

August 24.—Large black bug (blister beetle) eating the foliage.

August 25.—Sprayed field with arsenite of soda and bug disappeared.

August 28.—Plants and soil in fine condition. Very clean; no bugs. Rain produced marked improvement.

September 4.—Field clean and in satisfactory condition. Effect of drought still apparent. Many leaves turning brown, which may be due to arsenite.

September 11.—Beets making good progress. Other conditions almost as on the 4th.

September 19.—Marked improvement since the 11th. Dead leaves disappearing and foliage green and bright. Beets were evidently stunted by drought.

September 25.—Entire field shows marked improvement in every particular.

October 2.—Improvement continues, especially noticeable in appearance of leaves which are making a new growth.

October 9.—Field almost as on October 2.

October 11.—Samples taken to-day following rain on 10th. Ground very hard at a depth of 4 inches. Beets show a tendency to form subdivided roots and are hardly up to the average in size and shape.

October 15.—Fifty feet of fourth row of beets removed for first sample and forwarded to Washington.

With the first sample of beets, forwarded under date of October 15, the following comments were made:

We were unable to have the ground subsoiled, and this, in my opinion, has been slightly detrimental. The stand, however, is the best that we have had in years, though the dry weather in July and August resulted in smaller beets; in fact, for three or four weeks their growth seemed to be entirely checked, and the effect of the drought was seen in the wilting and dying of the leaves.

There was a marked difference between the beets grown on the unfertilized and fertilized plats, the latter standing the drought much better and presenting a better appearance, both as to foliage and growth, throughout the season.

The beets showed the same tendency as in 1903, to have subdivided roots—sometimes as many as four prongs being formed. This may have been due to lack of subsoiling, though in 1903 the ground was subsoiled at the proper time.

The weather is quite mild and conditions at present are not favorable for an early maturing of the beets since we have as yet had no severe frosts.

On October 24 five samples of beets were sent, three of which (plats 1, 3, and 5) were grown with fertilization and the others without. The description of these plats and their fertilization is as follows:

Plat 1.—Ten rows, 18 inches apart, making 0.09 of an acre. On May 17, when beets were just up, the following materials were applied: 10.5 pounds of nitrate of soda, 12.9 pounds acid phosphate, 3.6 pounds of potassium sulphate. On June 9 and 20 the application was repeated.

Plat 2.—Regular experimental plat from which sample was sent on October 15. Ten rows, 18 inches apart; no fertilizer applied.

Plat 3.—Eight rows, 22 inches apart. Same fertilizer applied as in the case of plat 1 and on the same dates.

Plat 4.—Eight rows, 22 inches apart. No fertilizer applied.

Plat 5.—On May 17 the following fertilizer was applied: 10.5 pounds of nitrate of soda, 5 pounds of bone, and 3.6 pounds of potassium sulphate. On June 9 this application was repeated, and on June 20 the following fertilizer was applied: 10.5 pounds of dried blood, 5 pounds of bone, and 3.6 pounds of potassium sulphate.

The following comments on the conduct of the work were reported on this date (October 24):

The total amount of plant food applied to the fertilized plats was 3 pounds of nitrogen in the nitrate of soda, 1.5 pounds of nitrogen in dried blood, 5.4 pounds of phosphoric acid, and 4.5 pounds of potash (K_2O). The bone contained 35.8 per cent of total phosphoric acid soluble in citrate and is therefore essentially a dicalcium phosphate.

The cultural data for all the plats are the same and have been previously given. It was a very noticeable fact throughout the season that the fertilized plats stood the drought much better than the unfertilized, and this was especially true of plat No. 5, to which the bone

was applied. At no time were there any dead leaves on this plat and the foliage remained green, not wilting as on the other plats.

The weather since October 15 has varied from hot to cold with irregular rains, and has not been of a nature to hasten the maturing of the beets.

Plats 3 and 4 are on somewhat lower ground than the others, and seem to be making a new growth. Two check rows are left between each plat.

YIELD AND CHARACTER OF BEETS HARVESTED.

A sample from plat No. 2 only was forwarded under date of October 28, accompanied by the following comments:

The weather the past week has been favorable to the maturing of the beets. There have been three killing frosts, and the days, while clear, have been moderate in temperature, the maximum being about 57°. The beets in all the plats show an increase in sugar, plat No. 1 leading with 16 per cent of sugar in the juice. Other conditions remain about the same as when the last report was made.

Under date of November 14, the following report was made on the samples shipped on November 6 and 11:

The beets during the past week have shown such an increase in sugar content that it seemed wise to send a sample from each of the plats, which was done on November 11. Until the past three or four days we have had no severe weather, but I think the beets have reached their maximum development.

I inclose a weather summary for the period covering the experiment. The amount of sunshine per day is of course estimated and can not be considered as exact. I have figured the sunshine from 6 a. m. to 6 p. m. during the entire period. It is probable that the average would not be far from this figure.

On November 26 the final report was made, as follows:

On November 18 a sample of beets was taken and the results were such that it seemed useless to continue the work any longer. In calculating the yield of beets this year it seems fair to base it upon the average of the samples taken from the different plats on November 4, 10, and 18. On this basis my estimate is as follows:

Plat No. 1, 12.8 tons per acre; No. 2, 10.5 tons; No. 3, 11.3 tons; No. 4, 8.5 tons, and No. 5, 12.5 tons per acre.

It will of course be remembered in using these figures that on plats 1 and 2 the rows were 18 inches apart while on Nos. 3, 4, and 5 they were 22 inches apart.

The illustrations (Plate I) show 10 beets from the experimental plat sampled on November 10, and also 10 of the imperfect beets, showing the tendency to multiplicity of roots manifested at the Indiana station during the past two years. These beets averaged 7.5 ounces in weight before capping and 6.4 ounces afterwards; there was 16.8 per cent of sugar in the juice and a purity of 83.6.

ANALYTICAL AND AGRICULTURAL DATA.

The analytical and agricultural data determined both at the Bureau of Chemistry and at the station are given in the following tables:

Agricultural and analytical data on beets grown at Lafayette, Ind., and forwarded to Washington, 1904.

Number and description of plats.	Average weight after topping.[a]	Estimated yield per acre.[b]	Sugar in juice.	Sugar in beet.	Purity coefficient.
	Ounces.	*Tons.*	*Per cent.*	*Per cent.*	
No. 1. Fertilized	9.4	11.2	17.5	15.9	85.6
No. 2. Unfertilized[c]	7.7	9.2	16.1	14.9	85.6
No. 3. Fertilized	8.5	10.1	17.3	15.9	85.5
No. 4. Unfertilized	8.8	7.4	16.7	15.2	86.0
No. 5. Fertilized	11.1	11.8	16.9	15.4	84.7
Average of fertilized plats	9.5	11.0	17.2	15.7	85.3
Average of unfertilized plats	8.3	8.3	16.4	15.1	85.8

[a] Data determined on 25 beets shipped to Bureau of Chemistry for analysis.
[b] Based on samples harvested November 4, 11, and 18.
[c] No. 2 is the experimental plat proper, and the average determined for the two unfertilized plats is used in making the graphic chart.

Averages of agricultural data reported by the Indiana Station, 1904.

Plat No.	Average.	No. of beets in 50 feet of row.	Weight after topping.		Yield per acre.	Loss in capping.	Yield tare.
			Total.	Average.			
			Pounds.	*Ounces.*	*Tons.*	*Per cent.*	*Tons.*
1	General	63	44.4	11.4	12.9	17.3	10.6
	November 4–18	.....	43.7	11.4	12.7	.....	.....
2	General	61	35.3	9.3	10.3	16.5	8.5
	November 4–18	.....	35.9	9.4	10.4	.....	.....
3	General	65	47.9	11.8	11.4	18.3	9.3
	November 4–18	.....	47.6	11.7	11.3	.....	.....
4	General	59	32.6	9.0	7.8	17.0	6.5
	November 4–18	.....	34.5	8.6	8.2	.....	.....
5	General	59	53.5	14.4	12.7	20.1	10.2
	November 4–18	.....	55.4	13.9	12.4	.....	.....

Average yields of fertilized and unfertilized plats[a] as reported by the station.

Average.	Fertilized plats, Nos. 1, 3, and 5.			Unfertilized plats, Nos. 2 and 4.		
	Average weight.	Yield per acre.	Yield tare.	Average weight.	Yield per acre.	Yield tare.
	Ounces.	*Tons.*	*Tons.*	*Ounces.*	*Tons.*	*Tons.*
General	12.8	12.3	10.0	9.2	9.1	7.5
November 4–18	12.3	12.1	.....	9.0	9.3	.....

[a] Plats 1 and 2, rows 18 inches apart; plats 3, 4, and 5, 22 inches apart.

Analytical data determined at the Indiana Station, comparing fertilized and unfertilized plats, 1904.

Date of sampling.	Plat 1, fertilized.		Plat 2, unfertilized.		Plat 3, fertilized.		Plat 4, unfertilized.		Plat 5, fertilized.	
	Sugar in juice.	Purity coefficient.	Sugar in juice.	Purity coefficient.	Sugar in juice.	Purity coefficient.	Sugar in juice.	Purity coefficient.	Sugar in juice.	Purity coefficient.
	Per ct.		*Per ct.*		*Per ct.*		*Per ct.*		*Per ct.*	
October 11			14.0	91.6						
October 22	14.2	84.6	14.1	93.4	13.0	85.2	13.2	89.4	14.3	89.0
October 28			14.6	86.0						
November 4	17.4	87.2	16.2	91.6	16.0	88.3	15.5	88.8	14.7	88.8
November 10	18.5	89.6	16.0	90.2	15.9	89.5	16.8	90.9	16.4	88.7
November 18	18.3	90.3	16.6	90.4	16.4	91.3	16.3	90.2	15.0	89.7
General average	17.1	87.9	15.3	90.5	15.3	88.6	15.5	89.8	15.1	89.1
Average November 4–18	18.1	89.0	16.3	90.7	16.1	89.7	16.2	90.0	15.4	89.1

Average analytical data for fertilized and unfertilized plats, as determined at the Indiana station, 1904.

Average.	Fertilized plats, Nos. 1, 3, and 5.		Unfertilized plats, Nos. 2 and 4.	
	Sugar in juice.	Purity coefficient.	Sugar in juice.	Purity coefficient.
	Per cent.		*Per cent.*	
General	15.8	88.5	15.4	90.2
November 4–18	16.5	89.3	16.3	90.4

Full details of the cultural data at the Indiana Station are given in the report of the special agent in charge. The average yield of the unfertilized plats was low, namely, 8.3 tons per acre. The yield of the fertilized plats was higher, 11 tons, but not so large as should be obtained. The percentage of sugar in the beets was very high, both from the fertilized and unfertilized plats, and the purity was exceptionally high. The data used in platting the results of the work were obtained on plats Nos. 2 and 4. The analytical data obtained at the Bureau of Chemistry compare very closely with those obtained at the Indiana Station, with the exception of the coefficients of purity. Uniformly, the results for purity obtained at Lafayette have been higher than those found at the Bureau of Chemistry, and this difference has not as yet been satisfactorily explained.

METEOROLOGICAL DATA.

The meteorological data indicate a favorable environment in so far as the temperature is concerned, for the production of a beet with a high content of sugar. The average temperature of the months from May to July, inclusive, is 67.8° F., and from August to October, 62.8°; from June to August, 70.7°; the mean temperature for the six months being 65.3°. The precipitation at the Indiana station

was well distributed for the proper growth and maturity of the beet, except during the month of September, when the rainfall was excessive. A very dry October, however, counteracted this excess, and thus brought the crop to a very fair maturity. In general, the meteorological data for the Indiana station for 1904 must be regarded as extremely favorable and apparently should have produced a larger yield per acre than was secured.

Meteorological data for Lafayette, Ind., 1904.

Month.	Mean temperature.	Precipitation.	Sunshine.	Clear days.	Cloudy days.
	°F.	*Inches.*	*Per cent.*		
May	61.4	2.98	47.0	5	20
June	69.6	2.05	70.0	7	19
July	72.3	6.12	80.9	15	10
Averages and totals	67.8	11.15	66.0	27	49
August	70.2	2.40	73.4	11	11
September	66.2	4.41	56.4	7	20
October	52.0	.78	67.9	17	13
Averages and totals	62.8	7.59	65.9	35	44
General averages and sum totals	65.3	18.74	66.0	62	93

THE NEW YORK STATION (GENEVA).

At the Geneva Station one-eighth of an acre was sown for the cooperative work on June 11, 20 inches between the rows, thinned on July 9 so as to leave the plants from 8 to 10 inches apart, and harvested on November 8. No samples were sent to the Bureau of Chemistry for analysis, but the following data were obtained at the station at the time of harvest:

Agricultural data:

Weight of 50 beets	pounds	56.3
Weight of 50 beets capped	do	45.0
Yield per acre	tons	19.0

Analytical data:

Sugar in juice	per cent	17.0
Sugar in beet	do	13.7
Coefficient		83.7

About 250 analyses of individual beets selected by the appearance of the tops before digging gave a sugar content of 17.7 per cent, while about 300 such analyses of beets selected at the same time from the appearance of the roots gave a sugar content of 18.1 per cent.

The beets grew very vigorously, holding their leaves until the harvest. No leaf spot or other diseases appeared. The meteorological data obtainable for Geneva are as follows:

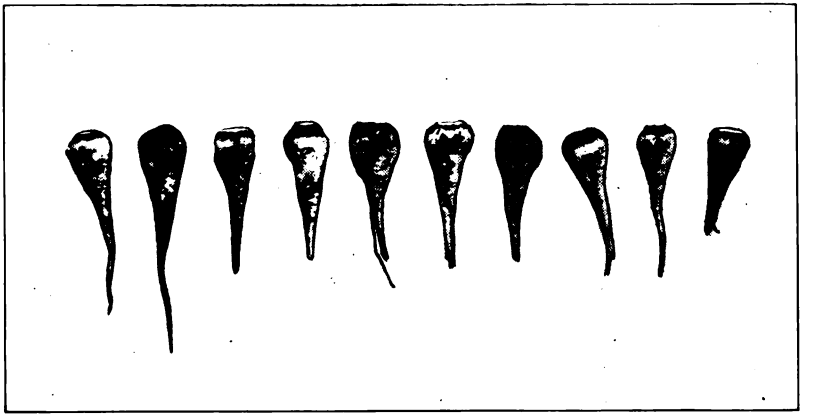

FIG. 1.—TEN BEETS HARVESTED FROM THE EXPERIMENTAL PLAT NO. 2, INDIANA STATION, NOVEMBER 10, 1904.

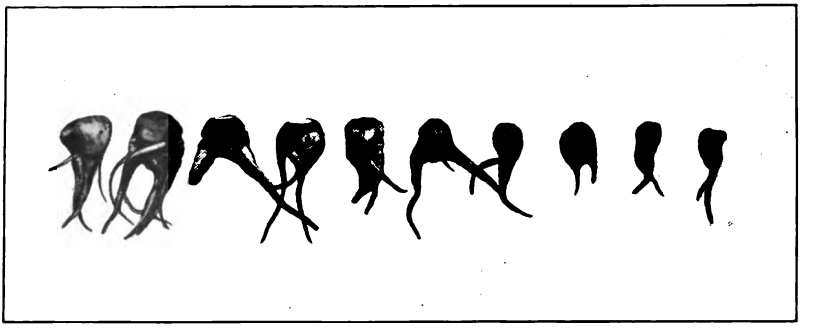

FIG. 2.—BEETS SHOWING THE TYPICAL MALFORMATION OF ROOTS AT THE INDIANA STATION.

Meteorological data for Geneva, N. Y., 1904.

Month.	Mean temperature.	Precipitation.	Sunshine.[a]	Clear days.[b]	Cloudy days.[b]
	°F.	*Inches.*	*Per cent.*		
May	60.3	4.04	63.0	19	9
June	67.8	3.37	66.0	18	9
July	70.0	5.73	63.0	18	10
Averages and totals	66.0	13.14	64.0	55	28
August	68.2	2.56	74.0	19	8
September	61.9	3.26	57.0		
October	48.4	2.06	48.0	15	9
Averages and totals	59.5	7.88	59.0	34	17
General averages and sum totals	62.8	21.02	61.5	89	45

[a] Data for Rochester, N. Y., about 40 miles northwest of Geneva.
[b] Data for Lyons, N. Y., about 13 miles northwest of Geneva.

The estimated yield per acre at Geneva was very high, namely, 19 tons. The reported percentage of sugar in the beet is quite low when compared with the reported percentage of the sugar in the juice. There appears to be a discrepancy here which is not explained. The mean temperature for May to October, 62.8° F., is divided into that for May to July, 66°, and August to October, 59.5°, while that for the three growing months of June, July, and August was 68.7°. The temperature was not very high at any time, July having the highest average, namely, 70°, while August had a markedly lower temperature, 68.2°. The precipitation was excessive in May and July, and conducive to growth during the other months. There was a greater amount of rainfall in September and October than was desirable for the proper maturity of the beets, and it appears that the growth must have been checked by the cool weather of October rather than by lack of moisture. The other meteorological data not obtainable for Geneva were taken from Rochester and Lyons. In general, the meteorological data appear favorable to the production of a beet of high quality, and in fact the purity of the beet is represented by the coefficient of 83.7.

THE NEW YORK STATION (ITHACA).

Under date of September 13, when sending the first sample, the following comments on the year's experiment were made:

These beets were not sown until the middle of June. This was the second sowing, the first having been a failure, which may account for the small yield—7.6 tons per acre. As half the plat was in sugar beet last year and the other half was not, I should like to send two samples for sugar determinations, for comparison. Leaf spot was present last year and made its appearance this year about the last of August on the half of the plat which was in sugar beets before, spreading gradually in about two weeks to the other end of the plat. This may affect the quality of the roots.

The two sets of samples were received and analyzed, the average only being given in the table in case of that part of the plat which was newly planted in beets. It will be noted that the beets from the latter were superior in every respect, there being a difference of 1.6 tons in yield, 1.9 per cent in sugar in the beet, and 4.3 in the purity coefficient.

Agricultural and analytical data on beets grown at Ithaca, N. Y., and forwarded to Washington, 1904.

PART OF PLAT IN BEETS BEFORE.

Date of receiving sample at Washington.	Average weight after topping.	Estimated yield per acre.[a]	Sugar in juice.	Sugar in beet.	Purity coefficient.
	Ounces.	*Tons.*	*Per cent.*	*Per cent.*	
September 17	5.6	.....	12.3	11.0	74.4
September 28	5.1	.....	12.4	11.4	76.0
October 1	5.1	.....	12.7	11.2	76.1
October 10	4.5	.....	13.5	12.4	74.6
October 17	6.4	.....	13.2	12.3	72.9
October 24	6.4	.....	17.3	15.8	82.4
October 28	8.0	.....	14.3	13.0	76.9
Averages	6.0	7.6	13.7	12.4	76.2

PART OF PLAT NEWLY PLANTED TO BEETS.

Averages	7.1	9.2	15.6	14.3	80.5

[a] Data determined at the station.

The yield per acre at the Ithaca Station was remarkably low, being only 7.6 tons on that portion of the plat which had been used for beet cultivation throughout the experiment, and 9.2 tons on the newly planted portion, both figures having been determined at the station. The percentage of sugar in the beet was satisfactory, being 12.4, but the purity of 76.2 is considerably below the standard, and combined with the low tonnage would not yield a very profitable return. The data for the portion of the plat used throughout the experiment are platted, and it is to be noted that the use of the data from the newly planted portion would have placed Ithaca above Geneva in the comparative charts; the inferiority in purity and tonnage, however, would make the crop as a whole still inferior to that produced at Geneva.

The average temperature from May to July was 64.5° F.; from June to August, 67.8°; from August to October, 58.7°; and for the six months, 61.6°. The precipitation was rather irregular, being greatest in May, when it was least needed, and smallest in August, when it was most needed. The beets must have suffered considerably in their development by the excessively dry weather of August and September. There was in general a predominance of cloudy days over the number of clear days. The conditions of temperature as indicated are favorable to the production of a beet of high character, but the

precipitation was not so distributed as to favor the production of a large crop.

Meteorological data for Ithaca, N. Y., 1904.

Month.	Mean temperature.	Precipitation.	Clear days.	Cloudy days.
	°F.	Inches.		
May	59.6	4.64	6	16
June	65.6	1.77	7	11
July	68.4	3.79	9	8
Average and totals	64.5	10.20	22	35
August	69.4	1.85	16	4
September	59.6	1.93	8	10
October	47.2	2.71	10	14
Average and totals	58.7	6.49	34	28
General average and sum totals	61.6	16.69	56	63

THE NORTH CAROLINA STATION.

The experiment conducted by the North Carolina Station was practically a failure, owing to the very unfavorable weather conditions, a long drought following the sowing on May 25 and 30, preventing germination for about three weeks, and another one of eight weeks' duration occurring in September and October. The beets were thinned on June 27 and July 9 and harvested on December 20, one sample being sent then and one on January 11, after the beets had been held in storage. The beets were grown at the test farm at Statesville, about 138 miles due west of Raleigh, the western part of the State being more favorable to this crop. In August there was considerable rain, and the plant made a start, only to be checked by the drought of September and October, most of the growth being made still later in the fall. The high quality of the crop, as shown by the analyses of the two samples sent, is to be attributed to the small size of the beets.

Agricultural and analytical data on beets grown at Raleigh, N. C., and forwarded to Washington, 1904.

Date of receiving sample at Washington.	Average weight after topping.	Estimated yield per acre.[a]	Sugar in juice.	Sugar in beet.	Purity coefficient.
	Ounces.	Tons.	Per cent.	Per cent.	
December 27, 1904	6.5	.....	15.4	14.0	80.61
January 14, 1905[b]	6.7	.....	16.4	14.9	82.01
Averages	6.6	1.5	15.9	14.5	81.31

[a] Estimate reported by station.
[b] Harvested December 20, on same date as the first sample, stored, and shipped January 11, 1905.

Meteorological data for Statesville, N. C., 1904.

Month.	Mean temperature.	Precipitation.	Sunshine.[a]	Clear days.	Cloudy days.
	°F.	*Inches.*	*Per cent.*		
May	65.2	2.07	64	11	3
June	72.4	5.74	59	8	5
July	74.6	4.01	48	7	2
Averages and totals	70.7	11.82	57	26	10
August	74.2	6.60	45	5	11
September	[b] 69.4	1.31	64	10	4
October	56.8	.12	84	21	3
Averages and totals	66.8	8.03	64	36	18
General averages and sum totals	68.8	19.85	61	62	28

[a] Data for Asheville, N. C., about 97 miles west of Statesville
[b] Four days missing.

The failure to obtain a crop at the North Carolina Station renders the discussion of the fragmentary data unnecessary. Although the germination of the crop was prevented by a severe drought in May, an inspection of the data for the precipitation will not indicate the severity of the disaster. The precipitation for May was sufficient, had it been properly distributed, to have secured germination, and for June it was very abundant. There was an abundant rainfall, as far as quantity is concerned, also in July and August. September was quite dry, and during October only twelve-hundredths of an inch of rain fell. An inspection of the data for temperature shows high temperatures for June, July, and August, averaging 73.7° F.—considerably above the limit suitable for the production of a beet rich in sugar. The high content of sugar in the beets, as before stated, must be attributed to their stunted growth, the beets being extremely small, and the yield only about 1½ tons per acre. It is a common experience that beets of this character always contain abnormal percentages of sugar.

THE VIRGINIA STATION.

The seed was planted at the Virginia Station on April 14, and the plants were cultivated at frequent intervals throughout the growing season, being thinned on June 16 and sampled on September 14 and 26 and October 8 and 21. The germination was reported as being almost perfect and the plants made a rapid growth, reaching full size about August 1, when the outer leaves began to turn dark and become dry. Later the beets made a second growth, which was checked by two weeks of dry weather the first part of September. The season, as a whole, is reported as being favorable, with much rain.

Agricultural and analytical data on beets grown at Blacksburg, Va., and forwarded to Washington, 1904.

Date of receiving sample at Washington.	Average weight after topping.	Estimated yield per acre.	Sugar in juice.	Sugar in beet.	Purity coefficient.
	Ounces.	*Tons.*	*Per cent.*	*Per cent.*	
September 20	9.9	10.7	14.7	13.5	80.6
October 1	9.0	.....	14.7	13.4	81.7
October 12	10.9	16.7	15.0	13.8	80.2
October 28	9.3	12.6	15.5	14.5	82.5
Average	9.8	13.3	15	13.8	81.2

Agricultural data determined at Blacksburg, Va., 1904.

Date of sampling.	Beets in 50 feet of row.		Estimated yield per acre.
	Number.	Total weight.	
		Pounds.	*Tons.*
September 15	69	45.0	13.1
September 27	.....	.....	14.5
October 10	65	57.3	16.7
October 22	49	34.8	10.1
Average	61	45.7	13.6

Meteorological data for Blacksburg, Va., 1904.

Month.	Mean temperature.	Precipitation.	Clear days.	Cloudy days.
	°*F.*	*Inches.*		
May	58.8	2.38	7	12
June	68.0	7.42	4	8
July	69.4	4.13	6	9
Average and totals	65.4	13.93	17	29
August	69.2	4.00	2	12
September	64.2	.27	.....	.....
October	52.4	.13	.....	.....
Average and totals	61.9	4.40	2	12
General average and sum totals	63.6	18.33	19	41

The data for the station at Blacksburg are interesting, because of the high altitude of the experimental field. This high plateau, by reason of its altitude, tends to correct the unfavorable features of an environment so far south for the growth of beets. The yield was satisfactory, although the beets were below the normal in size, the average weight before topping being 11.8, and after topping 9.8 ounces. The content of sugar was satisfactory, namely, 13.8 per cent, and the purity above the standard, being 81.2. The temperature data show in a striking manner the effect of the altitude. The mean temperature for May to July was 65.4° F.; August to October, 61.9°; for the six months, 63.6°; and for the three growing months, 68.9°. The precipitation was abundant during the greater part of the growing season. Although May was somewhat dry, June shows

an excessive rainfall, while July and August had an excessive rainfall as far as the needs of growth were concerned, and September and October were dry, thus favoring early maturity. The cloudy days far exceeded the clear ones; and it will be noticed that at no time did the temperature reach 70°, although July had a temperature of 69.4°. The conditions, in so far as temperature and precipitation were concerned, were very favorable to the production of a crop not only of fair size, but also of excellent quality.

THE WISCONSIN STATION.

Mr. F. W. Woll, of the Wisconsin Station, furnished, as usual, a very complete report of the sugar-beet work conducted at Madison, extracts from which report are given as follows:

About two-fifths of an acre of land was set apart for sugar-beet work in the spring of 1904, on a part of the same field on which sugar beets were grown last year. The field was plowed on April 24, dragged twice on April 29 and on April 30, and a fine seed bed was prepared by disking and harrowing on May 20. The beets were planted on the same day in drills 18 inches apart, and were thinned on June 15 to approximately 8 inches apart in the row. The beets were kept free from weeds during the growing period by wheel hand cultivator and hoe, the field being laid by on July 22.

The growth of the beets was very satisfactory during the early part of the season, when both the moisture and temperature conditions were favorable. Abundant moisture was also supplied during the months of August and September, but a short intermediate period of hot sultry weather occurred in the early part of August, which affected the beets injuriously, causing the leaves to droop and the lower ones to turn yellow, as if some fungous disease had attacked the plants. During the latter part of the growing period many new leaves appeared and the plants seemed to take on new life. This condition, in all probability, accounts for the relatively low sugar content and the low purity of the beets during the early fall months, as shown by the results of the chemical analyses made during September and October.

The sampling of the beets was begun on September 20 and was continued weekly until October 25, when the crop was harvested. The sugar contents of the samples dug from September 20 to October 17 were as follows: 12.77 per cent, 12.64 per cent, 12.33 per cent, 13.48 per cent, and 13.32 per cent. The estimated yields per acre ranged from 20.5 to 30.4 tons. The data obtained at harvesting time gave the following averages: Estimated yield per acre, 25.7 tons; sugar in the beet, 14.6 per cent; and purity coefficient, 87.1.

While the plan of growing sugar beets on the same land for several years in succession is not to be recommended, the results obtained show that under favorable climatic conditions and on land in a high state of fertility strong and healthy beets may be grown for a limited time without a change of crops in the successive seasons. During the past three years the yields obtained on the University farm have exceeded 25 tons to the acre, and the yields of sugar have exceeded 3 tons to the acre.

The following data obtained at the Bureau of Chemistry do not run quite as high as those obtained at the station, but still represent a very satisfactory crop:

Agricultural and analytical data on beets grown at Madison, Wis., and forwarded to Washington, 1904.

Date of receiving sample at Washington.	Average weight after topping.	Estimated yield per acre.	Sugar in juice.	Sugar in beet.	Purity coefficient.
	Ounces.	*Tons.*	*Per cent.*	*Per cent.*	
September 28	13.4	20.7	13.2	12.0	86.0
October 1	16.6	.....	13.5	12.2	82.3
October 10	14.9	16.4	12.9	12.1	81.1
October 17	13.4	.....	13.3	12.4	82.6
October 24	14.7	22.5	15.3	14.2	82.7
November 5	13.4	.....	15.7	14.5	84.4
Averages	14.4	19.9	13.9	12.9	82.2

Agricultural data reported by station, 1904.

Date.	Beets in 50 feet of row.		Estimated tonnage.
	Number.	Total weight.	
		Pounds.	*Tons.*
September 20	79	70.5	.....
October 4	60	62.5	18.1
October 12	.....	.....	23.7
October 18	70	87.5	25.4
October 31	.....	.....	25.0
Average	70	73.5	23.1

Meteorological data for Madison, Wis., 1904.

Month.	Mean temperature.	Precipitation.	Clear days.	Cloudy days.
	° *F.*	*Inches.*		
May	57.4	5.03	10	13
Jun	65.7	2.85	12	13
July	69.4	3.27	8	8
Average and totals	64.2	11.15	30	34
August	66.9	3.20	6	4
September	61.4	5.93	10	14
October	50.7	1.71	15	7
Average and totals	59.7	10.84	31	25
General average and sum totals	62.0	21.99	61	59

The agricultural data show a fine yield per acre, namely, 19.9 tons, and the beets are of a satisfactory size, the average weight after topping being 14.4 ounces. The sugar content is not quite so high as would be expected under the circumstances, but the purity is very satisfactory, 82.2. The mean temperature from May to July was 64.2° F., from August to October 59.7°, for the three growing months 67.3°, and for the six months 62°. The warmest month was July, with a temperature of 69.4°, while August was only slightly warmer

than June. The precipitation was overabundant during May and September, and it is more than probable that this excessive rainfall in September maintained the beets in vigorous growth, and to this cause the rather low content of sugar may be attributed. These data show in a striking manner how the distribution of the rainfall may serve to influence the sugar content even though the conditions of temperature tend to produce a high percentage of sugar. The number of clear days was slightly larger than that of the cloudy days at this station, notwithstanding the amount of rainfall.

EXPERIMENTS CONDUCTED IN IRRIGATED SECTIONS.

THE CALIFORNIA STATION.

The peculiar conditions existing at the California Station, together with the distance of the station from Washington, made it impracticable to conduct the experiment along the lines followed in regard to eastern locations, and therefore no analyses were made at Washington (except of the soils), and the report of Mr. G. W. Shaw, in charge of the cooperative work at the station, is submitted in full:

As in former years the beet plat on the Pomona substation tract comprised one-tenth of an acre. The ground was plowed, graded, and irrigated on February 24, 1904, after a comparatively dry season, as will be seen by reference to the climatic data. After plowing, the plat was thoroughly harrowed and worked to a good seed bed according to instructions. The seed was sown on March 2, in drills 18 inches apart, and a good stand was showing on March 10. The beets were thinned on April 15 leaving the plants 8 inches apart in the row.

Irrigation began on May 14, the water being applied as follows:

Irrigation data, Pomona, Cal., 1904.

Date of irrigation.	Amount of water remaining on plat.		
	Gallons.	*Cubic feet.*	*Acre-inches.*
May 14	10,000	1,336	0.37
May 30	8,000	1,069	.29
June 3	10,000	1,336	.37
June 11	6,000	802	.22
June 18	5,000	668	.19
June 27	4,000	534	.14
July 5	3,000	401	.11
July 12	2,500	334	.09
Totals	48,500	6,480	1.78

Irrigation was discontinued after July 12, as the beets appeared to be mature, but on September 13, about 5,000 gallons were used to soften the ground, which had become quite hard and dry. This amount, however, should not be counted as a part of the irrigation which influenced the crop, as the beets were plowed out on September 15, and pulled and weighed on September 19. The natural precipitation during the preceding fall and spring (that is, from September 27, 1903, to February, 1904, inclusive) amounted to 2.51 inches, and during the growing season (March to September), 6.74 inches, a total rainfall of 9.25 inches, which with the 1.78 inches of water received by irrigation gives a sum total of 11.03 inches, of which amount 8.52 inches were received after planting.

While the fall was dry and rather unfavorable the spring rains were well distributed and the season would be considered fair for the locality. Nearly all the moisture of the season was applied after planting, whereas the reverse was the case in 1902. The effect is quite noticeable, double the crop being secured this season. The meteorological data are as follows:

Meteorological data for Pomona, Cal., 1904.

Month.	Mean temperature.	Precipitation.	Sunshine.			Clear days.	Cloudy days.
			Actual.	Possible.	Percentage.		
	°*F.*	*Inches.*	*Hours.*	*Hours.*	*Per cent.*		
March	57.0	5.16	200	320	62.5	16	13
April	61.0	1.21	300	340	88.2	22	8
May	66.0	.18	310	430	72.1	25	6
Averages and totals	61.3	6.55	.....	.....	74.3	63	27
June	72.0	.00	380	440	86.1	30	0
July	74.0	.00	(a)	(a)	(a)	31	0
August	77.0	.19	340	400	85.0	29	2
September	73.0	Trace.	255	360	70.8	28	2
Averages and totals	74.0	.19	.....	.....	80.7	118	4
General averages and sum totals	67.7	6.74	.....	.....	77.5	181	31

[a] Data missing.

Each irrigation was followed by a thorough cultivation as soon as the ground was in condition to be worked. The agricultural data are as follows:

Agricultural data regarding beets grown at Pomona, Cal., 1904.

Date of harvest		September 29
Date of analysis		October 5
Relation of tops to beets at harvest	per cent	17.00
Weight of 6 topped beets at harvest	ounces	97.75
Weight of 6 topped beets when analyzed	do	92.00
Loss from drying	do	5.75
Loss from drying	per cent	6.90
Average weight of beets as analyzed	ounces	15.17
Estimated yield per acre	tons	10.50

As it is evident from these figures that the beets lose almost 7 per cent of their weight by drying in the time which elapses before they reach the laboratory, the results of the analyses as determined and as calculated to the original weight of the samples are given.

Analytical data determined at the Berkeley (Cal.) Station, 1904.

Data.	Density.	Sugar in juice.	Sugar in beet.[a]	Purity coefficient.
	° *Brix.*	*Per cent.*	*Per cent.*	
Result of analysis	19.71	15.50	14.26	78.63
Corrected to original weight	18.44	14.50	13.34	78.63

[a] The factor 92 used as determined by the hot aqueous method.

The sugar content is lower by about 1 per cent than that of 1902 and the purity is nearly 8 points lower. This may have been due to the rains occurring on August 19, at which time 0.19 inch fell, but it hardly seems possible that the beets would not have fully recovered from this during the thirty days of hot weather that followed. The purity is very low as compared with that of the beets generally received from the same locality.

To test the efficiency of single sampling, as practiced this year in representing the average of the plat, as well as for the purpose of noting the variation in the sugar content between contiguous beets, 30 consecutive single beets were taken from the same row and sent to the laboratory, numbered according to their positions in the row, and the sugar in the beet was determined. The results are as follows:

Analyses of single beets taken from the same row, 1904.

Consecutive numbers in row.	Weight of topped beet.	Loss of weight by drying.	Sugar in the beet.		Consecutive numbers in row.	Weight of topped beet.	Loss of weight by drying.	Sugar in the beet.	
			As analyzed.	Calculated to original weight.				As analyzed.	Calculated to original weight.
	Ounces.	*Per cent.*	*Per cent.*	*Per cent.*		*Ounces.*	*Per cent.*	*Per cent.*	*Per cent.*
1	5.3	9.9	15.2	13.8	17	9.3	[d]	[d]	[d]
2	9.5	7.0	19.0	17.7	18	13.4	7.3	12.6	11.7
3	[b] 9.2	8.4	14.6	13.5	19	12.7	16.9	15.6	13.4
4	41.3	6.0	Lost.	Lost.	20	8.6	15.8	17.2	14.8
5 [a]					21	11.9	2.6	16.1	15.7
6	19.7	3.9	16.6	15.9	22 [c]				
7	[b] 1.0				23 [c]				
8	10.4	7.0	15.6	14.6	24	9.2	8.4	14.2	13.1
9	20.5	4.6	14.0	13.3	25 [a]				
10	18.3	4.6	12.0	11.4	26	28.3	4.7	13.0	12.4
11 [c]					27	5.3	8.4	16.0	14.6
12	13.1	13.0	14.4	12.7	28 [c]				
13	9.6	8.3	14.6	13.4	29	2.3	10.9	14.6	13.1
14	2.5	16.6	18.6	15.9	30 [c]				
15 [c]									
16	9.4	7.9	18.4	17.0	Average	10.9	8.6	15.4	14.1

[a] A small, shriveled beet. [b] Excluded from average. [c] No beet. [d] Data missing.

These results are interesting from several points of view. In the first place the average of the analyses indicates the reliability of the original method of sampling as fairly representing the entire plat. Secondly, a great variation in individual samples is shown, suggesting the great care which is essential for securing a small number of beets to fairly represent the entire tract. It is evident that with careless work it would be possible to secure widely differing results as the 30 beets analyzed varied in sugar content from 11.4 to 17.7 per cent. Also, there is clearly shown the absolute necessity, in this climate at least, of calculating to the original weight where samples are kept for a few days before analysis.

The meteorological data from the Pomona Station show an average temperature of 67.7° F., including the months from March to September, which period represents the season in this locality. In this connection it must be taken into consideration that the principal growth of the beets occurs during the early part of the season. March, April, and May are comparable with May, June, and July for the nonirrigated regions. It is eyident that it is the first three months of the growing season in which the temperature produces its principal effects. In this time the real character of the beet is formed and its habit of storing sugar fixed. It will be seen, therefore, that the mean temperature of March, April, and May, 61.30° F., was quite favorable to the development of a beet of the character given, namely, of 13.3 per cent of sugar. Further, it is noticed that irrigation was withdrawn in July, after which time the beet simply approached the condition of maturity. Thus, while June, July,

August, and September were very warm, it is probable that little if any growth took place after July.

The yield per acre is very fair and the sugar content good, but the purity is somewhat low, not reaching the minimum of 80, which is considered the lowest purity compatible with the economic production of sugar from the beet.

The individual analyses of 30 beets are of interest to show the wide variation which may occur in the content of sugar in beets grown in juxtaposition. These variations are often explained by the corresponding variation in the size of the beets, the small beets, if healthy, containing a larger percentage of sugar. The rapidity with which beets dry out in arid climates, such as that of California, is also illustrated by this statement.

THE COLORADO STATION.

The season of 1904 is reported as having been very favorable to the beet crop in northern Colorado. The sugar factory in the district of the experiment station reported an average tonnage of slightly less than 15 tons per acre from 6,400 acres. A number of large fields reported over 25 tons per acre.

The experimental plat at Fort Collins (Field F, plat 6) was weeded and thinned on May 31, and irrigated three times—on July 4, July 15, and August 2, respectively. The plat was harvested on October 22 and gave a yield of 16.86 tons of clean beets per acre, the tare being 8 per cent.

The agricultural and analytical data reported by Mr. A. H. Danielson, of the Colorado Station, are given in the following table. Of interest in connection with these data are the climatic conditions as shown in the table of meteorological data, a part of which was observed at Cheyenne, Wyo., 40 miles northeast of Fort Collins, being the nearest point at which sunshine observations were made.

Agricultural and analytical data determined at Fort Collins, Colo., on beets grown at that station, 1904.

Date of sampling.	Beets in 50 feet of row.		Average weight after topping.	Estimated yield per acre.	Sugar in juice.	Sugar in beet.	Purity coefficient.
	Number.	Total weight.					
		Pounds.	*Ounces.*	*Tons.*	*Per cent.*	*Per cent.*	
September 28[a]	.....	.....	12.8	.....	16.7	15.4	83.5
October 12	64	72.0	18.0	16.5	17.4	16.2	88.4
October 15	64	64.0	16.0	14.8	18.0	16.7	87.9
October 20[b]	.....	.....	16.0	.....	17.5	15.8	87.6
October 22	.....	69.8	21.4	16.0	18.0	16.4	89.1
Averages	64	68.6	16.8	15.8	17.5	16.1	87.3

[a] Determination made at Washington, D. C., on this date. [b] Average of 12 samples.

Meteorological data for Fort Collins, Colo., 1904.

Month.	Mean temperature.	Precipitation.	Sunshine.[a]			Clear days.[a]	Cloudy days.[a]
			Actual.	Possible.	Percentage.		
	° *F.*	*Inches.*	*Hours.*	*Hours.*	*Per cent.*		
May	53.7	5.37	[b] 110.7	[b] 213.5	[b] 52	5	11
June	59.9	1.68	248.1	451.9	55	8	12
July	65.6	1.99	316.1	458.6	69	17	5
Averages and totals	59.7	9.04	.....	.....	58	30	28
August	67.1	.71	279.1	427.4	65	9	6
September	59.2	1.09	265.7	374.0	71	11	7
October	48.9	.39	282.0	343.9	82	17	6
Averages and totals	58.4	2.19	.....	.....	73	37	19
General averages and sum totals	59.1	11.23	.....	.....	65	67	47

[a] Observations for Cheyenne, Wyo., 40 miles northeast of Fort Collins. [b] For 15 days only.

Mr. Danielson makes the following remarks on the irrigation practiced and its effect:

The amount of water applied at each irrigation has not been measured, but I judge that it would not exceed four-tenths of a foot per acre in the earlier irrigations, decreasing to about two-tenths of a foot per acre in depth in the later irrigations. The beets are always cultivated as soon as the ground is dry enough after each irrigation until the plants become too large to admit the passage of implements between the rows. It is usual also to use a shovel plow in the latter part of the season, making furrows at the same time.

I have repeatedly noticed a peculiar fact in connection with the irrigation of beets in this section, which has been corroborated by several expert sugar-beet men and may be stated briefly as follows: If beets under irrigation are kept supplied with water so that they do not become too dry at any time, and especially if water is applied toward the end of the season when the beet is maturing, it will mature earlier with a larger percentage of sugar and a larger tonnage than if the crop has suffered for water, especially during the latter part of the season; that is, sugar beets from which water has been withheld will continue green and growing until very late in the season; the beet will not mature well, and is often caught by the frost; nor will the sugar content be very high.

The agricultural data show that the beets from the Colorado Station were of good size, reaching an average of 16.8 ounces after topping.

The yield was good, namely, 15.8 tons per acre, and the content of sugar in the beet extremely high (16.1 per cent). The purity also was above the average, being represented by the coefficient 87.3. The meteorological data show the mean temperature from May to July to be 59.7° F., from August to October, 58.4°, from June to August, 64.2°, and for the entire season, 59.1°. The temperature in Colorado may be compared directly with the temperature data for the nonirrigated regions, as its growing season, unlike that of California, is coincident with that of nonirrigated stations. The low temperature, according to the general relation which has already been established, was highly favorable to the development of a beet rich in sugar. Even the warmest month, August, had a

temperature of only 67.1°. The rainfall was sufficient for the growth of the plant for the first three months, but was unevenly distributed. May had a precipitation of 5.37 inches, while the precipitation for June and July was less than 2 inches. August, September, and October were quite dry, and without irrigation the growth of the plants would have been prematurely checked. The data show that this section of Colorado is capable of producing not only a yield satisfactory to the farmer but also a crop which is exceedingly rich in sugar, with a high purity. Beets of this character, with proper treatment at the factory, should yield nearly 300 pounds of sugar per ton.

The following table is a comparison of the results obtained on the experimental plat No. 6, which had received no fertilization for two years, and those obtained on the adjoining plats which had been fertilized in 1903, as indicated, no part of the field (F) having received any fertilizer in 1904:

Comparison of fertilized and unfertilized plats, 1904.

No. of plat.	Fertilizer applied in 1903.	Yield per acre.	Tare.	Total weight of 12 samples.			Sugar in—		Purity coefficient
				Beets and leaves.	Beets only.	Leaves.	Juice.	Beets.	
		Tons.	*Per ct.*	*Lbs.*	*Lbs.*	*Lbs.*	*Per ct.*	*Per ct.*	
5	Bone meal, 200 pounds per acre; nitrates, 150 pounds per acre	17.90	10.2	19.0	13.6	5.4	18.0	16.2	86.5
6	None	16.86	8.0	17.6	12.5	5.1	17.5	15.8	87.6
7	Bone meal, 200 pounds per acre	16.08	9.75	20.3	14.7	5.6	17.8	16.0	87.5

In commenting on the fertilizer experiments, Mr. Danielson writes as follows:

Our fertilizer experiments with sugar beets are still being continued and the results are not ready for publication; but I can summarize briefly the practical results of the work. Nitrogen in any form on our soils seems to be the most effective in increasing the tonnage. In commercial fertilizers the nitrogen from nitrates has been the most effective, raising the tonnage on nitrogen-poor ground from 10 tons to as much as 17 tons per acre, and from 20 to 24 and 25 tons per acre. Stable manure will also have practically the same effect with the additional benefit derived from the humus added to our humus-poor soils.

An excess of nitrogen on the sugar beets in my experiments has lowered the sugar content from one-half to one and one-half per cent, and the purity from 1 to 5 points. We found that a little available phosphorus in the form of acid rock, bone meal, or acid bone meal will tend to prevent this lowering of the sugar content and purity, and also seems to be very beneficial in giving hardiness to the young beet early in the season. Interesting facts have been observed in regard to the other elements of plant food experimented with, but these are the most practical points.

THE SOILS.

DESCRIPTIVE NOTES ON UNIRRIGATED SOILS.

Washington, D. C.—The beet plat on the Potomac flats at Washington was located very near that of 1902, the data being used as determined for that year. This soil, as previously stated, is an artificial deposit of material dredged from the bottom of the Potomac River.

Lafayette, Ind.—Soil samples were removed on April 29 from six places on the experimental plat, the surface soil to a depth of 9 inches and the subsoil 12 inches, i. e., from 9 to 21 inches. The history of this plat is as follows:

1881–1884.—Connecticut experiment on potatoes.
1885.—Wheat.
1886.—Oats.
1887.—Corn, heavily manured.
1888–1890.—Corn.
1891–1894.—Corn, heavily manured.
1895.—Kafir corn, fertilized with 92 pounds of bone, containing 34 per cent of phosphoric acid; 92 pounds of sodium nitrate, containing 16 per cent of nitrogen, and 46 pounds of muriate of potash, containing 50 per cent of potash.
1896.—Kafir corn, fertilized with 17 pounds of dissolved boneblack, containing 16 per cent of phosphoric acid; 6½ pounds of sodium nitrate, containing 16 per cent of nitrogen, and 75 pounds of muriate of potash, containing 50 per cent of potash—(K_2O).
1897.—Kafir corn.
1898–1899.—Clover.
1900.—Soy beans and cowpeas plowed under; sown to wheat October 11.
1901–1902.—Wheat.
1903.—Corn.
1904.—Beets.

Lexington, Ky.—The sugar beets having been grown on the same plat of loamy bluegrass soil as in the four previous years, the soil analyses were not repeated, but the data obtained in 1903 are inserted in the table for comparison.

Agricultural College, Mich.—The soils were sampled on October 28, air dried, and forwarded on November 15, with the following history of the plat from which they were taken, no fertilizer having been applied since 1890:

1890.—Wheat, yield 15 bushels per acre.
1891–1892.—Oats, yield 56 bushels per acre.
1893.—Wheat, yield 10 bushels per acre.
1894.—Oats, yield 25 bushels per acre.
1895.—Oats, yield poor.
1896.—Oats, yield 48 bushels per acre.
1897.—Oats, yield 40 bushels per acre.
1898.—Oats, yield small.
1899.—Fallow, sown to wheat (winter fife) in the fall.
1900.—Wheat, mostly winter killed.

1901.—Clover.
1902.—Oats, yield 50 bushels per acre.
1903.—Clover, yield 2 tons per acre.
1904.—Beets.

Ithaca, N. Y.—The soil on which these experiments were conducted is reported as being a sandy loam of good depth and fertility which was well limed and fertilized in 1904. Two samples of beets were sent, one from fresh land and one from the plat on which beets had been growing for four years. It is regretted that no new soil analyses were made, but the analysis of this soil made in 1902 is inserted in the table as a general indication of its character.

Geneva, N. Y.—The soil used was a clay loam, quite uniform throughout, and very much like that on which beets were grown in 1902, the plats being separated only by farm road. The data determined in 1902 are accordingly used in the table of soil analyses. This field has been used for farm crops in rotation ever since it came into the possession of the station and for the past five years the crops have been as follows: 1889, oats; 1890, wheat seeded to clover and timothy; 1891 and 1892, meadow; 1893, corn.

Statesville, N. C.—The beet plat was situated on a ridge, the soil being a rather dry clay loam, comparatively fresh. Corn was grown on the land in 1903, a crop of about 40 bushels to the acre being obtained.

Blacksburg, Va.—For several years the beets have been grown on various portions of the garden, a different plat being used each year. The plat selected in 1904 was grown last year in garden crops for an early harvest and then was planted to late Indian corn. The land was covered with manure in the fall of 1902 and had been so treated for several years previous, but no such application has been made since that date. The soil is a fairly rich loam, such as occurs on the bench land of this section just above the streams. The uplands here are not rich, but the rock is nearly always lime. This particular soil is drift, but it is not what is called bottom or muck lands.

Madison, Wis.—The soil is a clay loam, with a heavy clay subsoil, and has a decided tendency to bake after rains. A part of the field was in sugar beets in 1902 and in rape or pease in 1903. This field has been in cultivation for at least 30 years, and has been brought to a high state of fertility by the application of barnyard manure for the past 12 years or more.

DESCRIPTIVE NOTES ON IRRIGATED SOILS.

Pomona, Cal.—While the particular location of the plat for the work of 1904 was different from that selected in 1902 yet the soil characteristics were essentially the same with the exception that the subsoil was far less leachy, it having been found to be impossible

in the former location to supply the amount of moisture necessary to produce a reasonable tonnage. As to its general physical character the soil would be classed as sandy and its general chemical character, as determined at the California Station, is given in the report for 1902.[a] The analyses made at the Bureau of Chemistry of the samples sent in 1904 are given in the general table below.

Fort Collins, Colo.—This plat in 1904 was planted in beets for the second year without fertilizer and was sampled very near the same spot as in the preceding year. The plat was in grain in 1902 and in beets in 1901.

COMMENT ON ANALYSES OF SOILS.

The analytical data representing the composition of the soil are obtained by two methods of solution: (1) By using concentrated hydrochloric acid, in which practically all of the soil constituents soluble in acid are obtained; and (2) by using dilute hydrochloric acid, which solution represents the amounts of potassium and phosphoric acid which may be regarded as immediately available for the growth of the crop.

The following table shows the results of analyses of the soils used in the cooperative experiments in 1904:

Chemical analysis of sugar-beet soils, 1904.

[Percentages based on water-free soil.]

NONIRRIGATED SOILS.

Serial No.	Locality.	Description.	Nitrogen.	Soluble in 1.115 HCl.				Soluble in N/200 HCl.	
				K_2O.	CaO.	MgO.	P_2O_5.	P_2O_5.	K_2O.
			Per ct.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
3131	Statesville, N. C.	Soil	0.078	0.29	0.06	Trace.	0.04	0.0001	0.0098
3132	do	Subsoil	.063	.33	.02	Trace.	.04	.0001	.0080
24898[b]	Ithaca, N. Y	Soil	.17	.21	.35	0.45	.18	.00107	.0114
24899[b]	do	Subsoil	.06	.66	2.00	.84	.09		
3123	Lafayette, Ind.	Soil	.224	.62	.33	.46	.11	.0018	.0086
3124	do	Subsoil	.161	.80	.29	.76	.08	.0001	.0043
2147[c]	Lexington, Ky.	Soil	.238	.50	.54	.18	.51		
2148[c]	do	Subsoil	.127	.29	.45	.21	.11		
25125[b]	Washington, D. C.	Soil	.18	.39	.47	.51	.03		
3133	Blacksburg, Va.	Soil	.141	.45	.09	.34	.11	.0002	.0124
3134	do	Subsoil	.050	.50	.12	.36	.04	.00015	.0056
3137	Agricultural College, Mich.	Soil	.169	.30	.52	.27	.05	.00015	.0038
3138	do	Subsoil	.091	.19	.34	.09	.04	.00005	.0096
1754 (S.& F)[b]	Geneva, N. Y	Soil	.17	.56	.56	.82	.09	.0001	.0087
1755 (S.& F)[b]	do	Subsoil	.10	.89	.81	1.27	.09		
3129	Madison, Wis.	Soil	.195	.42	.64	.51	.12	.0011	.0043
3130	do	Subsoil	.085	.46	.43	.54	.11	.00031	.0024

IRRIGATED SOILS.

3121	Pomona, Cal.	Soil	0.040	0.68	1.66	1.62	0.09	0.0040	0.0098
3122	do	Subsoil	.042	.62	1.67	1.99	.10	.0051	.0011
3135	Fort Collins, Colo.	Soil	.170	.89	3.20	1.02	.11	.0002	.0129
3136	do	Subsoil	.113	.89	8.72	1.46	.11	.00005	.0089

[a] U. S. Dept. Agr., Bureau of Chemistry Bul. No. 78, p. 36.
[b] Analysis for 1902 samples.
[c] Analysis for 1903 samples.

Considering the nonirrigated soils in respect of the content of nitrogen, the richest are those from Lexington, Ky., and Lafayette, Ind., while the soils from Ithaca, Blacksburg, Agricultural College, Geneva, and Madison form a group having a moderate amount of nitrogen and differing only slightly from each other in this respect. The soils at the other stations are not so well provided with nitrogen, having only about half as much as the soils of the stations in the first group. In every case there is less nitrogen in the subsoil than in the soil, as is to be expected.

In regard to the potassium soluble in strong hydrochloric acid, it is seen that the soil having the largest quantity is from Indiana and the soil having the smallest quantity is from Ithaca. In several cases the subsoil is found to contain more potassium than the soil, and this is notably true in the case of Ithaca, Lafayette, Blacksburg, and Geneva. In regard to the phosphoric acid soluble in the strong acid, the largest quantity is found in the sample from Lexington, and the smallest (always excluding that from Statesville, N. C.), from the Michigan Station. In regard to the lime, the largest quantity is found in the soil from Wisconsin and the smallest quantity in the sample from Blacksburg, Va. In one instance there is more lime in the subsoil than in the soil, in the case of Ithaca, where the same relation is observed in the case of potassium.

It is to be noticed that there is found a much larger proportion of lime in the irrigated soils than is usually found in the nonirrigated areas, with the exception of the lime in the subsoil at Ithaca. All the soils and subsoils of the irrigated stations show large quantities of carbonate of lime. This is especially true of the soil from Fort Collins, which approaches in texture the chalky soils of parts of England. The large amount of lime in the Fort Collins soil shows that there must have been originally large quantities of lime present, for Fort Collins is not situated in a very dry climate, the data showing that it received almost as much rain as some of the nonirrigated stations during the growing season.

In the following table is given a comparison of the yields at the various stations and the average amounts of plant foods in the soils and subsoils. Attention may again be called to the fact that it is not possible to correlate these factors with scientific exactness, such a comparison only being possible for purposes of making conclusive deductions when the soils are subjected to the same environment, as was the case in the pot experiments conducted during a series of years by this Bureau.

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Yield of beets and soil data, 1904.

[Average of figures for soil and subsoil.]

NONIRRIGATED SOILS.

Station.	Yield of beets.	Nitrogen.	Soluble in 1.115 HCl.		Soluble in N 200 HCl.	
			Potash.	Phosphoric acid.	Potash.	Phosphoric acid.
	Tons.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Statesville N. C.	1.5	0.072	0.31	0.04	0.0089	0.0001
Ithaca, N. Y.	7.6	.12	.44	.14	.0114	.00107
Lafayette, Ind.	8.3	.193	.71	.10	.0065	.0009
Lexington, Ky.	8.9	.183	.40	.31	.....	.....
Blacksburg, Va.	13.3	.095	.48	.08	.0090	.0009
Washington, D. C.[a]	14.9	.18	.39	.03	.....	.....
Agricultural College, Mich.	15.2	.13	.25	.05	.0067	.0001
Geneva, N. Y.	19.0	.135	.725	.09	.0087	.0001
Madison, Wis.	19.9	.14	.44	.12	.0034	.00071
IRRIGATED SOILS.						
Pomona, Cal.	10.5	0.041	0.66	0.10	0.0055	0.0046
Fort Collins, Colo.	15.8	.142	.89	.11	.0109	.0004

[a] Soil only.

The data, however, show in a general way what has been observed before, that the quality of the soil has but little to do with the sugar content of the beet. It is true that if the soil be so very poor that the beet is very much stunted in its growth, reaching a weight of only 2 or 3 ounces at maturity, the poverty of the soil would act in this way to increase the percentage of sugar in the beet, but this is only incidental since any unfavorable condition would act in the same way, as, for instance, a deficient rainfall or imperfect cultivation. It is quite certain that a very rich soil, in the presence of an environment otherwise favorable to a large growth, would have the opposite effect, for the overgrown beet is prone to have an excess of cellular tissue, to become pithy, and be less sweet. In this case, also, the effect is largely fortuitous, for it is evident that in any condition of overfertility the beets may be grown so close together as to prevent large size, and thus their percentage of sugar may be largely conserved.

It is undoubtedly true that the use of certain fertilizers in definite proportions may tend to increase the percentage of sugar. This is particularly true of potash and phosphoric acid. On the contrary, an abundant supply of nitrogenous fertilizer may tend to depress the content of sugar. In the latter case the effect is probably due to a tendency to increase the growth, while in the former case it may be partly due to securing a proper ripening of the beet, and thus avoiding overgrowth, and partly to actual saccharigenic influences of the fertilizers themselves. Whatever the physiological action may be, it is evident that neither soil nor fertilizer is the dominant or even an important factor affecting the percentage of sugar in the beet.

During the course of the five-year investigation no attempt has been made to study specifically the effect of fertilizers upon the sugar content of the beet, but incidentally it has been borne in mind. Such special studies have, however, been made by others and a brief outline of the results obtained is appended. The conclusion drawn by MM. Hébert and Charabot is entirely in harmony with the deductions made in the incidental study of the subject during this investigation.

In a somewhat elaborate study entitled "The influence of the nature of the environment upon the organic composition of the plant," by these investigators, appearing in the Bulletin de la Société Chimique de Paris[a] the following conclusions are drawn from the summary of the analytical results obtained:

1. Vegetable assimilation, at least up to a certain limit, remains almost invariable in proportion to the growth; the relative organic composition at the end and at the beginning of the vegetation is found to be almost the same, with a reservation in regard to nitrogen.

2. The assimilation in the plants belonging to the several groups is similar from the organic point of view as it is from the mineral standpoint; the fertilizers or the salts added did not modify sensibly the relative composition of the plant. The substances added act in an absolute (nonrelative) manner, whether it be in diminishing the vegetable production if they are harmful, or in increasing it if they are helpful.

This conclusion is very important as regards the use of fertilizers which are thus seen to act only on the production of vegetable matter without modifying sensibly its composition.

An abstract of the results obtained by K. Andrlík[b] is as follows:

In experiments with phosphoric acid alone Mr. Andrlík found that with small additions a small increase in sugar content was secured. Large applications of phosphoric acid, no matter in what form, whether as superphosphate, basic slag, or mineral phosphate, also acted favorably, both in increasing the yield and the sugar content of the beet. These larger amounts, however, did not increase either the quantity or the quality of the beet proportionately to the amounts added.

Moderate quantities of nitrogen in the form of Chile saltpeter had a diminishing effect upon the sugar content of the beet, and it was found that the quantity of soda in the roots was twice as great as where no Chile saltpeter had been employed. The conclusion was therefore reached that Chile saltpeter when used alone, even in moderately small quantities, exerts an unfavorable influence upon the sugar content of the beet. Moderate quantities of chlorid of potassium or sulphate of potassium produced favorable results upon the sugar content of the beet but did not increase the tonnage per acre. Larger quantities of potash fertilizers, however, did increase the yield as well as the sugar content in a marked degree. The influence of the sulphate of potassium was somewhat more marked than that of the chlorid. The combination of Chile saltpeter and superphosphate acted favorably upon the beets in producing a larger tonnage but did not change the sugar content. Where very large quantities of this mixed fertilizer were used the ash content of the beet was markedly increased so as to interfere with its proper manufacture, but the sugar content was not diminished. Potash and phosphoric acid combined in moderate quantities increase both the yield per acre and the sugar content and to a much greater extent than when used singly.

The combination of three fertilizing elements, viz, chlorid of potash, superphosphate, and Chile saltpeter, had a very marked effect not only in increasing the crop, but especially in increasing the sugar content. The combination of these three plant foods in moderate

[a] Third series, volume 29–30, No. 24, December 20, 1903, p. 1239.

[b] Zeit. des Ver. der deut. Zuc.-Ind., September, 1903, p. 948.

quantities shows itself to be extremely favorable. Also quite as favorable results were obtained by a combination in which the superphosphate was replaced by an equivalent amount of basic slag except that the quality of the beet in this combination was not quite so good. Equally favorable results were obtained by replacing the superphosphate or basic slag by mineral phosphate. It was also noticed particularly that in the combination of the three elements each one of them was much more readily utilized by the plant than when they were used separately. With very intensive fertilization, using chlorid of potash, Chile saltpeter, and phosphoric acid, the yield was very markedly increased, but the quality of the beet deteriorated by reason of the presence of an excess of salts.

SUMMARY OF DATA.[a]

The following is a summary of the data secured in the experiments of 1904:

Agricultural and analytical data, 1904.

WHERE IRRIGATION WAS NOT USED.

Station.	Mean weight of topped beets.	Estimated yield per acre.	Sugar in beet.	Coefficient of purity.
	Ounces.	*Tons.*	*Per cent.*	
Washington, D. C.	12.5	14.9	11.4	76.1
Lexington, Ky.	9.8	8.9	11.5	72.4
Ithaca, N. Y.	6.0	7.6	12.4	76.2
Madison, Wis.	14.4	19.9	12.9	82.2
Geneva, N. Y.[a]	14.4	19.0	13.7	83.7
Blacksburg, Va.	9.8	13.3	13.8	81.2
Statesville, N. C.[b]	6.6	1.5	14.5	81.3
Lafayette, Ind.	8.3	8.3	15.1	85.8
Agricultural College, Mich.	9.9	15.2	15.5	86.0

WHERE IRRIGATION WAS PRACTICED.

Pomona, Cal.	10.9	10.5	13.3	78.6
Fort Collins, Colo.	16.8	15.8	16.1	87.3

[a] Data determined at the station.
[b] Data not platted nor discussed under general conclusions.

Meteorological data, May to October, 1904.

WHERE IRRIGATION WAS NOT USED.

Station.	Temperature.	Precipitation.	Clear days.	Cloudy.	Sunshine.
	°*F.*	*Inches.*			*Per cent.*
Washington, D. C.	67.3	19.1	79	36	62.0
Lexington, Ky.	68.4	13.0	94	24	73.0
Ithaca, N. Y.	61.6	16.7	56	63	.....
Madison, Wis.	62.0	22.0	61	59	.....
Geneva, N. Y.	62.8	21.0	[a] 89	[a] 45	61.5
Blacksburg, Va.	63.6	18.3	19	41	.....
Statesville, N. C.	68.8	19.2	62	28	[b] 61.0
Lafayette, Ind.	65.3	18.7	62	93	66.0
Agricultural College, Mich.	61.5	14.4	[c] 52	[c] 63	[c] 59.0

WHERE IRRIGATION WAS PRACTICED.

Pomona, Cal.[d]	67.7	6.7	181	31	77.5
Fort Collins, Colo.	59.1	11.2	[e] 67	[e] 47	[e] 65.0

[a] Data for Lyons, N. Y.
[b] Determined for Asheville, N. C.
[c] Data for Detroit, Mich.
[d] Data from March to September.
[e] Determined for Cheyenne, Wyo.

[a] For geodetic data see five-year summary, p. 48.

CONCLUSIONS DRAWN FROM RESULTS OF EXPERIMENTS IN 1904.

The average data, agricultural, analytical, meteorological, and geodetic, for the year 1904, as collected in the tables of summaries and platted on the graphic charts, show the following relations:

In regard to the size of beets harvested, it is noticed that the results at only two of the stations fulfilled the requirements of profitable beet culture from the farmer's point of view. These are the stations at Madison, Wis., and Geneva, N. Y., where the weight of the beets after topping was almost a pound. The smallest beets reported from the stations which appear in the graphic charts were from Ithaca. The size of the beets at this station, as well as that of the beets from Lexington, Blacksburg, Lafayette, and Agricultural College, was greatly below the required standard. The beets from Washington occupy a mean position between these extremes, having a weight of 12.5 ounces.

The stations at Madison, Geneva, Agricultural College, and at Washington represent what should be considered typical yields, varying from 19.9 to 14.9 tons. It is evident that, from the farmer's point of view especially, the principal effort should be devoted to securing yields of approximately the magnitude mentioned. The yield at Blacksburg of 13.3 tons is fairly satisfactory and would be a profitable crop if the other conditions were favorable, while the tonnages at Lexington, Ithaca, and Lafayette are below the limit of profitable agriculture.

Respecting the sugar in the beet, four groups of the stations presented on the graphic charts may be made (disregarding decimals), the first including Michigan and Indiana, with 15 per cent; the second including Geneva and Blacksburg, with 13 per cent; the third including Ithaca and Madison, with 12 per cent; and the fourth including Lexington and Washington, with 11 per cent. It is evident that all the beets analyzed might prove profitable for sugar making in so far as the sugar content is concerned.

Respecting purity, two groups may be made, the beets from Madison, Geneva, Blacksburg, Lafayette, and Agricultural College constituting the first group, having a purity of over 81, Lafayette and Agricultural College showing the highest, while the beets from the other stations, Washington, Lexington, and Ithaca, form a group having a purity ranging from 72 to 76. This low purity, combined as it is with a correspondingly lower content of sugar, would render the manufacture of sugar from these beets less profitable.

A comparison of the beets from the two irrigated stations shows the great superiority of the beets grown at the Colorado Station, which is doubtless to be largely attributed to the low temperature at that station.

A comparison of the meteorological data is also interesting. The highest mean temperature from May to October is found at Lexington, 68.4° F., and the lowest mean temperature at the Michigan Station, 61.5°, with Ithaca only one-tenth degree higher. The stations may be placed in two groups in respect of temperature, the first of which would include Washington, Lexington, and Lafayette, with the higher temperature, and the second the other collaborating stations. In respect of rainfall the heaviest precipitation occurred at the Wisconsin Station, amounting to 22 inches, and the smallest at Lexington, namely, 13 inches. In regard to the number of clear days the highest number is found at Lexington and the lowest at Blacksburg. The largest number of cloudy days was reported from Lafayette and the smallest from Lexington. The percentage of sunshine could not be obtained from all the stations, but as reported the highest percentage was at Lexington and the lowest at the Michigan Station.

At the two irrigated stations a striking difference in mean temperature is noticed, Pomona having by 8.6° a higher temperature than Fort Collins for their respective growing seasons. In regard to the precipitation it is seen that Fort Collins can hardly be called purely an irrigated section, since the precipitation was almost as great as that at Lexington. Pomona has almost three times as many clear days as Fort Collins, and the percentage of sunshine also at the California Station was 12.5 per cent higher than that used for Fort Collins.

In regard to the geodetic data[a] the stations having the longest days are Madison and Geneva, each with a day of 14 hours and 44 minutes. Close to these are Agricultural College, Mich., where the average day has 14 hours and 42 minutes, and Ithaca, with 14 hours and 41 minutes. The shortest day is at Blacksburg, 14 hours and 14 minutes, and next to this is Lexington, with 14 hours and 18 minutes. The greatest altitude is found at Blacksburg, 2,100 feet, and the lowest at Washington, 37.5 feet. At the irrigated stations a marked difference is noted in altitude, Fort Collins having almost 5,000 feet, while Pomona has only 861, another disadvantage of the California Station. The interrelations of these various factors and their influence upon the sugar content of the beet are more clearly set forth in the graphic charts.

In chart No. 1 are graphically represented the percentage of sugar in the beet at the various stations, the percentage of sunshine, the number of clear days in the month, and the latitude of the station. In regard to the percentage of sugar in the beet, the chart shows that for the first time the Geneva Station does not hold the first place. Attention has already been called to the remarkable differ-

[a] See page 48.

ence in the percentage of sugar in the expressed juice of the beets grown at Geneva and the percentage of sugar in the beet itself. Had

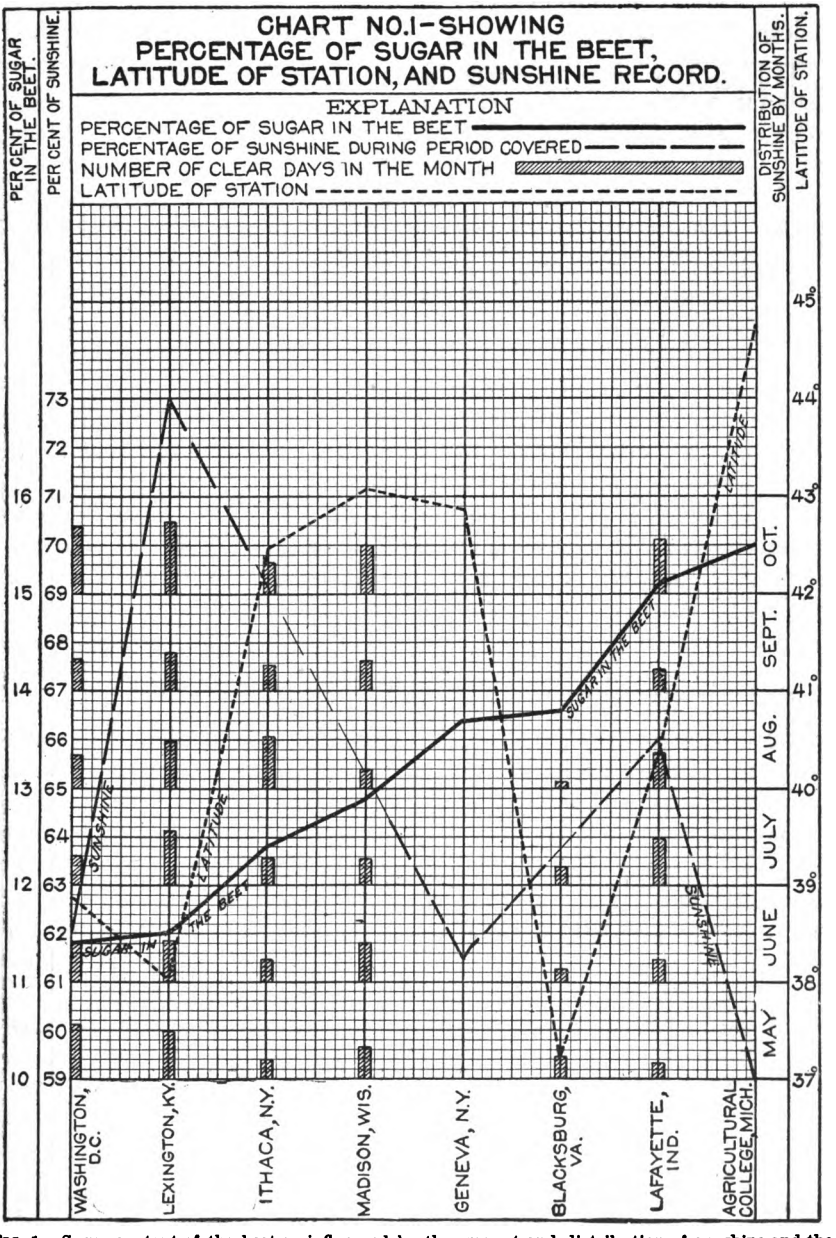

FIG. 1.—Sugar content of the beet as influenced by the amount and distribution of sunshine and the latitude of the station, 1904.

the calculations been made upon the basis of the percentage of the sugar in the juice, the Geneva Station would have retained its

position. The curve is remarkable in this respect, that it indicates a higher content of sugar at such stations as Washington and Lexington, which in former years have shown a percentage of sugar of less than 10. Although the percentage of sugar is higher than

FIG. 2.—Sugar content of the beet compared with the purity and the temperature and average length of day at the various stations, 1904.

in other years, these two stations retain their positions in the two lowest places. The line representing the latitude follows in general the sugar content, with the exception of the station at Blacksburg. This variation, due to the altitude of the station, while it interferes

with the symmetry of the curve, is nevertheless extremely interesting from the point of view of these investigations. It is evident that the influence of latitude has two components, namely, length of day and degree of temperature. The curve for Blacksburg indicates that, of these two components, the one representing the degree of temperature is by far the more important. There seems to be but little relation shown in these investigations between the hours of sunshine and the sugar content. In this respect the data for the present year are entirely in harmony with those of previous years.

In chart No. 2 are found graphically represented the percentage of sugar in the beet, the coefficient of purity in the juice, the temperature, and the average length of day. In this chart we find that two sets of the graphically illustrated data coincide in general in their magnitude and direction with the content of sugar, namely, the purity of the juice and the average length of day. In regard to the latter point there is again a noted variation in the case of Blacksburg, which has the shortest day of all the stations under observation. This fact is again illustrative and interesting, since it shows that it is not alone the hours of sunshine, or rather the hours of daylight, which form the dominant factor in the production of sugar. . There is no doubt at all that there is a tendency to diminish the content of sugar by diminishing the hours of daylight. The greatest difference in the length of day between Blacksburg with the shortest day, and Madison and Geneva with the longest day, is 30 minutes. Yet the richness in sugar of the beet at Blacksburg was greater than that at either of the two stations mentioned. This illustrates the fact that of the two components in the factor of the long day—namely, duration of the light and temperature—the latter is the more important. The temperature curve illustrates that the percentage of sugar is in inverse ratio to the elevation of the temperature; that is, in general, the higher the temperature the lower the content of sugar, and vice versa. For the present year this curve is not at all regular. There is an especial variation from it in the case of Lafayette, but if we take the two extreme points of Lexington and Agricultural College and connect them with a straight line, the general tendency of the factor above mentioned will be illustrated. The line which represents the sugar content of the beets of the various stations and the line which represents the average temperature at the same stations tend to form a figure like that of the letter X when platted graphically.

In chart No. 3 are platted the percentage of sugar in the beet, the total amount and monthly distribution of rainfall, and the altitude of the station. In this chart there is evidently but little relation between the lines representing the factors of environment and the sugar content. The Blacksburg Station again introduces a great irregularity, since its altitude is so much greater than that of any other station.

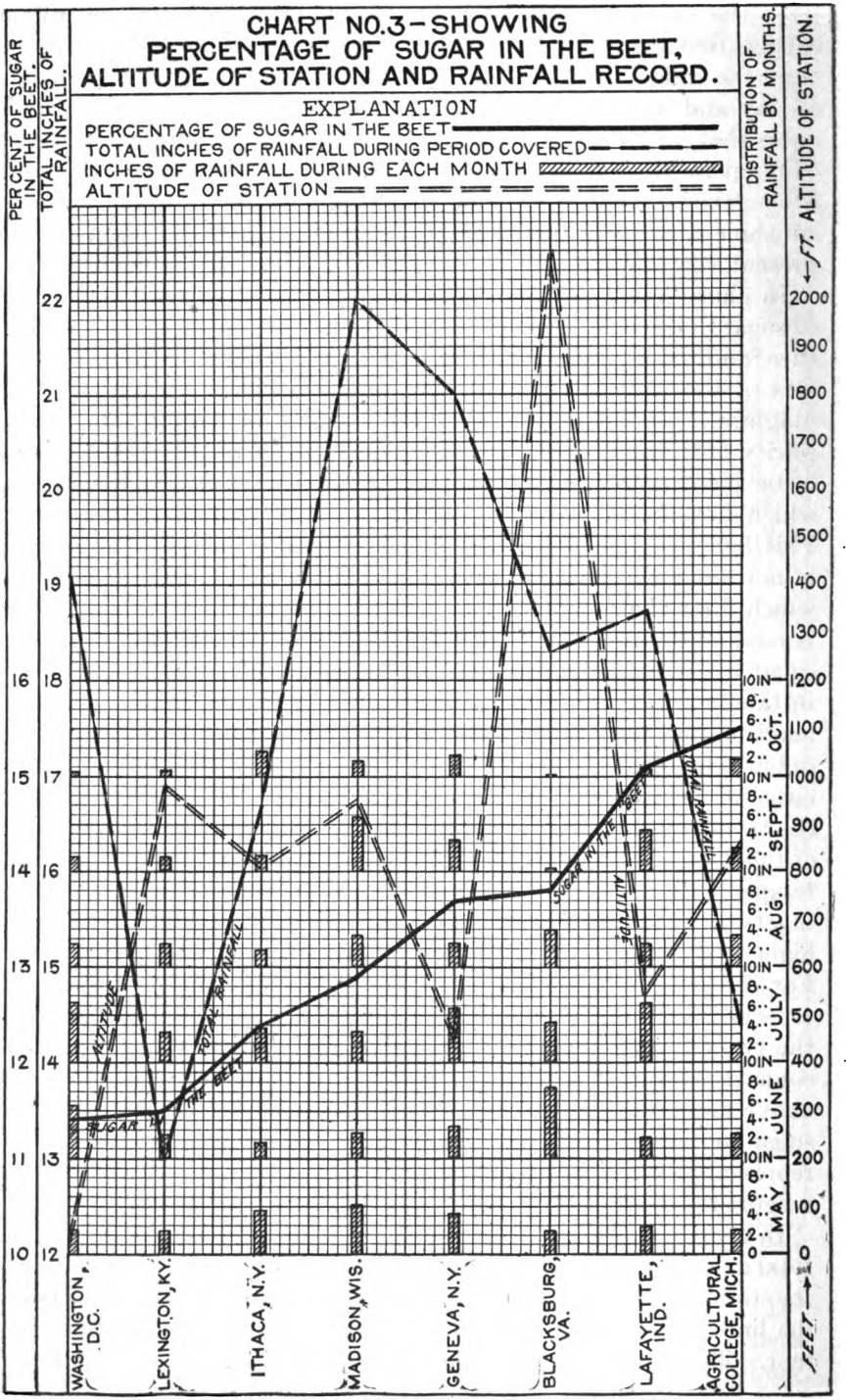

FIG. 3.—Sugar content of the beet as influenced by the amount and distribution of the rainfall and the altitude of the station, 1904.

The one really valuable lesson conveyed by this chart lies in showing that a high altitude may offset a low latitude in its relation to the content of sugar; this is shown in a remarkable manner in the case of the Blacksburg Station. It is perfectly evident from the data which have been collected and arranged that if the Blacksburg Station could be reduced to practically sea level, the character of the beets produced would be lower than that of the beets at Washington and Lexington, thus well illustrating the fact that the most depressing effects on the sugar content are produced by the combination of low latitude and low altitude. This is proved by the data obtained at Washington. The most satisfactory influences for the production of a beet rich in sugar are secured by the combination of a high latitude and a high altitude. There is an apparent exception to this in the case of the stations at Ithaca and Geneva. Ithaca is considerably higher than Geneva and only 26′ farther south, resulting in a lower temperature, and yet the beets grown at Ithaca have been uniformly inferior to those produced at Geneva. This relation is further discussed under the summary of the five years' work.

SUMMARY OF FIVE-YEAR EXPERIMENT.

Having discussed in previous reports[a] and in the foregoing pages of the present report the individual data collected at the different cooperating stations during the years 1900 to 1904, inclusive, it remains to bring these individual data together for comparison, in order to determine the average potency of each of the factors in the environment, and to this end the average figures for the five years are collected in tabular form and also expressed graphically, as has been done for each individual year. In the tables following are given the annual averages of agricultural, analytical, and meteorological data for the five years, and also in the general tables these averages for the five years as a whole, and the geodetic data as well:

DETAILED ANNUAL SUMMARIES OF DATA, 1900–1904.

Agricultural and analytical data for stations where irrigation was not used.

Place and year.	Estimated yield per acre.	Sugar in beet.	Coefficient of purity.
Lexington, Ky.:	*Tons.*	*Per cent.*	
1900	10.0	7.8	69.5
1901	8.0	9.0	71.0
1902	8.9	7.3	70.9
1903	6.3	9.5	72.0
1904	8.9	11.5	72.4
Averages	8.4	9.0	71.2
Washington, D. C.:			
1900	15.0	8.3	69.1
1901	8.1	8.5	67.3
1902	26.1	8.4	72.4
1903	14.6	8.7	71.6
1904	14.9	11.4	76.1
Averages	15.7	9.1	71.3
Blacksburg, Va.:			
1900	.....	.....	.....
1901	10.0	13.1	77.6
1902	16.7	11.7	74.4
1903	.....	.....	.....
1904	13.3	13.8	81.2
Averages	13.3	12.9	77.7
Madison, Wis.:			
1900	9.0	15.2	86.2
1901	11.0	12.7	77.4
1902	31.8	12.7	82.0
1903	19.5	11.6	79.0
1904	19.9	12.9	82.2
Averages	18.2	13.0	81.4
Lafayette, Ind.:			
1900	.....	9.9	83.0
1901	5.4	14.6	82.5
1902	.....	.....	.....
1903	8.9	13.2	81.6
1904	8.3	15.1	85.8
Averages	7.5	13.2	83.2
Ithaca, N. Y.:	*Tons.*	*Per cent.*	
1900	15.0	14.0	81.9
1901	12.6	14.6	79.9
1902	18.0	12.5	81.9
1903	13.4	12.2	75.0
1904	7.6	12.4	76.2
Averages	13.3	13.2	79.0
Ames, Iowa:			
1900	.....	11.7	76.9
1901	12.9	14.1	80.2
1902	.....	.....	.....
1903	15.6	15.5	81.8
1904	.....	.....	.....
Averages	14.2	13.8	79.6
Agricultural College, Mich.:			
1900	15.8	13.1	80.0
1901	10.2	14.6	81.5
1902	12.5	13.5	86.9
1903	.....	.....	.....
1904	15.2	15.5	86.0
Averages	13.4	14.2	83.6
Geneva, N. Y.:			
1900	.....	15.5	83.9
1901	13.8	15.8	83.9
1902	16.1	13.9	84.5
1903	15.6	14.2	89.4
1904	19.0	13.7	83.7
Averages	16.1	14.6	85.1

[a] U. S. Dept. of Agr., Bureau of Chemistry Buls. 64, 74, 78, and 95.

Agricultural and analytical data for stations where irrigation was practiced.

Place and year.	Estimated yield per acre.	Sugar in beet.	Coefficient of purity.	Place and year.	Estimated yield per acre.	Sugar in beet.	Coefficient of purity.
Logan, Utah:	*Tons.*	*Per cent.*		Fort Collins, Colo.:	*Tons.*	*Per cent.*	
1900	18.9	12.1	84.2	1902	24.0	13.0	79.4
1901	23.4	14.2	79.1	1903	21.5	15.1	85.0
1902	14.4	13.4	80.4	1904	15.8	16.1	87.3
1903				Averages	20.4	14.7	83.9
1904							
Averages	18.9	13.2	81.2				
Pomona, Cal.:							
1902	5.0	15.0	86.5				
1903							
1904	10.5	13.3	78.6				
Averages	8.0	14.2	82.5				

Meteorological data for stations where irrigation was not used.

Place and year.	Mean temperature.		Precipitation.	Clear days.	Sunshine.
	June, July, and August.	Six months.			
Lexington, Ky.:	°F.	°F.	*Inches.*		*Per cent.*
1900	76.3	72.1	16.90	100	73.0
1901	76.1	69.3	16.23	95	75.0
1902	77.3	69.3	16.60	83	76.1
1903	72.9	68.8	11.50	80	62.0
1904	73.3	68.4	13.09	94	73.0
Averages	75.2	69.6	14.85	90	71.6
Washington, D. C.:					
1900	76.8	69.0	19.34	81	64.0
1901	76.1	71.7	24.50	96	64.5
1902	73.8	68.6	23.50	80	67.0
1903	71.6	67.2	21.26	81	57.0
1904	72.6	67.3	19.10	79	62.0
Averages	74.2	68.8	21.54	83	62.9
Blacksburg, Va.:					
1900					
1901	70.1	63.8	32.08	79	53.7
1902	70.7	65.8	15.20	74	
1903					
1904	68.9	63.6	18.30	19	
Averages	69.9	64.4	21.86	57	53.7
Madison, Wis.:					
1900	71.0	66.4	16.30		
1901	73.9	65.6	14.33	48	
1902	67.1	60.5	27.40	55	58.0
1903	67.0	62.0	25.58	61	
1904	67.3	62.0	22.00	61	
Averages	69.3	63.3	21.12	56	58.0
Lafayette, Ind.:					
1900	74.3	69.8	30.5	64	64.7
1901	76.5	68.6	16.4	74	69.9
1902	71.1				
1903	69.4	65.9	17.4	82	58.0
1904	70.7	65.3	18.7	62	66.0
Averages	72.4	67.4	20.75	71	64.7

Meteorological data for stations where irrigation was not used—Continued.

Place and year.	Mean temperature.		Precipitation.	Clear days.	Sunshine.
	June, July, and August.	Six months.			
Ithaca, N. Y.:	°F.	°F.	*Inches.*		*Per cent.*
1900	70.4	65.1	13.8	50	69.2
1901	70.5	63.4	17.4	49	66.0
1902	65.9	60.4	23.3	41	.....
1903	63.9	60.2	22.7	42	46.0
1904	67.8	61.6	16.7	56	.....
Averages	67.7	62.1	18.8	48	60.4
Ames, Iowa:					
1900	73.1	68.2	36.30	89	62.7
1901	76.8	67.9	16.15	127	69.9
1902	.....	.....	.....	.....	.....
1903	69.2	63.6	22.43	105	60.0
1904	.....	.....	.....	.....	.....
Averages	73.0	66.6	24.96	107	64.2
Agricultural College, Mich.:					
1900	69.4	64.5	17.50	81	59.2
1901	70.2	62.8	19.84	96	61.8
1902	65.5	60.5	27.40	55	58.0
1903	.....	.....	.....	.....	.....
1904	66.9	61.5	14.40	52	59.0
Averages	68.0	62.3	19.79	63	59.6
Geneva, N. Y.:					
1900	71.4	66.0	15.00	.....	.....
1901	72.2	65.5	18.03	.....	.....
1902	68.1	63.1	20.20	.....	.....
1903	66.0	62.6	25.60	.....	.....
1904	68.7	62.8	21.00	89	61.5
Averages	69.3	64.0	19.97	.....	.....

Meteorological data for stations at which irrigation was practiced.

Place and year.	Mean temperature.		Precipitation.	Clear days.	Sunshine.
	June, July, and August.	Six months.			
Logan, Utah:	°F.	°F.	*Inches.*		*Per cent.*
1900	70.2	63.0	6.2	138	81.2
1901	70.3	64.0	7.37	130	76.3
1902	68.1	60.3	4.2	116	78.5
1903	.....	.....	.....	.....	.....
1904	.....	.....	.....	.....	.....
Averages	69.5	62.4	5.9	126	78.7
Pomona, Cal.:					
1902	70.2	70.0	.59	67	70.0
1903	.....	.....	.....	.....	.....
1904[a]	70.7	67.7	6.7	181	77.5
Averages	70.5	68.9	3.65	124	73.8
Fort Collins, Colo.:					
1902	66.1	60.0	14.8	94	62.5
1903	65.1	59.0	7.1	.....	.....
1904	64.2	59.1	11.2	67	65.0
Averages	65.1	59.4	11.0	80	63.8

[a] Data for March to September.

GENERAL SUMMARIES OF DATA, 1900–1904.

Table of general averages of agricultural and analytical data for the five years, 1900–1904.

STATIONS WHERE IRRIGATION WAS NOT USED.

Station.	Estimated yield per acre.	Sugar in the beet.	Purity coefficient.	Average temperature.	
				June to August.	May to October.
	Tons.	*Per cent.*		°*F.*	°*F.*
Lexington, Ky.	8.4	9.0	71.2	75.2	69.6
Washington, D. C.	15.7	9.1	71.3	74.2	68.9
Blacksburg, Va.[a]	13.3	12.9	77.7	69.9	64.4
Madison, Wis.	18.2	13.0	81.4	69.3	63.3
Lafayette, Ind.[b]	7.5	13.2	83.2	72.4	67.4
Ithaca, N. Y.	13.3	13.2	79.0	67.7	62.1
Ames, Iowa[a]	14.2	13.8	79.6	73.0	66.6
Agricultural College, Mich.[b]	13.4	14.2	83.6	68.0	62.3
Geneva, N. Y.	16.1	14.6	85.1	69.3	64.0
STATIONS WHERE IRRIGATION WAS PRACTICED.					
Logan, Utah[a]	18.9	13.2	81.2	69.5	62.4
Pomona, Cal.[c]	8.0	14.2	82.5	70.5	[d] 68.9
Fort Collins, Colo.[a]	20.4	14.7	83.9	65.1	59.4

[a] Data for 3 years.
[b] Data for 4 years.
[c] Data for 2 years.
[d] 1904 data for March to September.

General averages of meteorological data (May to October) for the five years, 1900–1904.

STATIONS WHERE IRRIGATION WAS NOT USED.

Station.	Temperature.	Precipitation.	Clear days.	Sunshine.
	°*F.*	*Inches.*		*Per cent.*
Lexington, Ky.	69.6	14.9	90	71.6
Washington, D. C.	68.8	21.5	83	62.9
Blacksburg, Va.	64.4	21.9	57	53.7
Madison, Wis.	63.3	21.1	56	.....
Lafayette, Ind.	67.4	20.8	71	64.7
Ithaca, N. Y.	62.1	18.8	48	60.4
Ames, Iowa.	66.6	25.0	107	64.2
Agricultural College, Mich.	62.3	19.8	63	59.6
Geneva, N. Y.	64.0	20.0	.....	.....
STATIONS WHERE IRRIGATION WAS PRACTICED.				
Logan, Utah[a]	62.4	5.90	126	78.7
Pomona, Cal.[b]	68.9	3.65	124	73.8
Fort Collins, Colo.[a]	59.4	11.00	80	63.8

[a] Three years' data.
[b] Two years' data; 1904 data for March to September.

Summary of geodetic data.

STATIONS WHERE IRRIGATION WAS NOT USED.

Station.	Average length of day.	Latitude.	Altitude.
	h. m.	° ′ ″	*Feet.*
Lexington, Ky	14 18	38 02 25	979.0
Washington, D. C	14 23	38 53 23	37.5
Blacksburg, Va	14 14	37 14 00	2,100.0
Madison, Wis	14 44	43 04 36	955.0
Lafayette, Ind	14 30	40 23 00	542.0
Ithaca, N. Y	14 41	42 27 00	810.0
Ames, Iowa	14 38	42 02 00	917.0
Agricultural College, Mich	14 42	44 45 00	847.0
Geneva, N. Y	14 44	42 53 00	453.0

STATIONS WHERE IRRIGATION WAS PRACTICED.

Logan, Utah	14 37	41 44 00	4,506.0
Pomona, Cal	13 58	34 03 00	861.0
Fort Collins, Colo	14 32	40 35 00	4,994.0

DISCUSSION OF FIVE-YEAR AVERAGES.

TONNAGE.

It is not advisable to discuss each of the tables of the summary separately, as the purpose of the investigation will be realized by the study of the table of averages. The agricultural data show some very curious results. It is seen that in the five years the yields per acre at Washington, Blacksburg, Madison, Ithaca, Ames, Agricultural College, and Geneva are fairly satisfactory, being in each case over 12 tons. Two of the stations, namely, Lexington and Lafayette, show a yield of approximately half a crop only, and Raleigh, from which only two years' data were obtained, shows practically a complete failure of the crop, and is therefore excluded from the summary. Moreover, it must be remembered that the tonnage figures have been estimated in all cases upon the weights of beets from very small areas, and thus it is evident that these results may not be strictly accurate. It is, nevertheless, true that these data show with a considerable degree of accuracy the comparative yields at the various stations.

The practical failure of the crop at Raleigh appears to have been due more to the uneven distribution of the rainfall than to any other source, in so far as the meteorological data throw any light upon the subject. In so far as the possibility of producing a large crop is concerned, there is no reason to believe that the station at Raleigh would necessarily occupy such an inferior position.

PERCENTAGE OF SUGAR IN THE BEET.

These are by far the most important of the agricultural data collected, since the special object of the investigation was to consider the effect of the environment upon the content of sugar alone, and not

upon the general composition of the beet. The stations are arranged in the table of general averages in accordance with the percentage of sugar, the lowest being placed first. First, attention should be called to the well-known fact that a phenomenally small yield or small-sized beets tends to increase in an abnormal way the percentage of sugar in the beet. The beet being a plant which by long continued selection and cultivation has formed a habit of producing sugar, tends to exercise that habit even under the most adverse circumstances. The habit of sugar forming, therefore, may be said to be a ruling passion in the beet, strong even in poverty, and the actual storage room of the small beet being limited, it is only natural to find it more fully stocked with the sugar produced. This point must be fully considered in comparing the sugar content of the beets produced at Lexington and Lafayette with those from the other stations. It is perfectly reasonable to suppose that had the crops at these stations been normal the percentage of sugar would have been greatly reduced. Any slight displacement, therefore, in the natural order in which the stations would have appeared (considering temperature and sugar content) does not in any way interfere with the general proposition which has been established throughout this long series of observations, viz, that temperature, or, in other words, latitude, is the most potent element of the environment in the production of a beet rich in sugar.

Again, Geneva, which not only produced the largest crop next to Madison, but also the richest beets, should, under normal conditions, have occupied the position held in the table by Ithaca, considering their relative temperatures and altitudes, but not their latitudes. Although Geneva is about 35 miles farther north, by reason of its lower altitude the average temperature for the five years is higher at Geneva than at Ithaca. Many modifying circumstances, which influence to a greater or less degree the effect of the temperature upon sugar production, have been active in the general problem, and are discussed under the following caption. These modifications, however, are of so slight a nature as not to decrease the value of the general conclusions.

TEMPERATURE.

NONIRRIGATED SECTIONS.

The average temperature is given in the general table, both for the whole period of six months and for the three most important growing months—June, July, and August. There is a very marked relation between the average temperature and the sugar content of the beet, although, as has already been mentioned, there are some variations from the general rule, the several factors of the environment interacting on each other so as to modify these general relations. It is seen

that, although Lexington is farther south than Washington, and thus would naturally have a considerably higher temperature, it is about 942 feet higher, and this altitude has a tendency to diminish the temperature. It must be remembered, however, that Washington, by reason of its propinquity to the sea, has a climate which is modified to a greater or less extent by the influence of the ocean, whereas Lexington has practically an intracontinental climate, being removed from all bodies of water, not even having the modifying influences of a river. This accident of situation is one of the circumstances explaining the slightly higher temperature of the Lexington station, and the fact that only half a crop was produced also tends to place the beets grown at Lexington in the relation to the Washington crop that theory would predict, despite the slight difference in percentage of sugar in the beet of one-tenth per cent in favor of the Washington crop.

The most conspicuous departure from the general rule is shown in the data from Ithaca. The mean temperature at Ithaca is less than at any other of the collaborating stations, being 0.2° F. less than at Agricultural College, Mich., and 1.9° less than at Geneva, only 35 miles north. The inferiority of the beets grown at Ithaca is due to some cause which does not clearly appear in the agricultural and meteorological data. Numerous modifying conditions may, however, be suggested. The inferior size of the beet grown at Ithaca, the small crop, and the markedly low purity are to be kept in mind, as well as the inferiority in sugar content. The comments of Mr. J. W. Gilmore, of the Ithaca Station, made in response to a letter from the Bureau of Chemistry calling attention to the peculiar relations apparently existing between the beets grown at Ithaca and at Geneva, are of general interest and are submitted in part as follows:

Your letter of recent date regarding the factors which influence the quality of sugar beets here in Ithaca has been received and I have given the matter considerable attention, inasmuch as I have been much interested in the points which you bring out. I have observed for some time that better sugar beets were grown north of us, both at the north end of Cayuga Lake and also between Cayuga and Seneca lakes in the vicinity of Geneva, than in the vicinity of Ithaca. I refer both to the sugar content and purity as well as to the tonnage. While I have never studied this matter in detail, yet I believe the following factors are influential in bringing about such conditions:

In the first place, the soil at the north end of Cayuga Lake and in the vicinity of Geneva seems to be better adapted physically for sugar beets than it is here. Several years ago, when the Binghamton sugar factory was in operation, a number of contracts for sugar beets were let in this locality and they proved to be practically unprofitable, while the beets have been grown for the factory successfully in the neighborhood of Union Springs and farther north. I think the physical condition of the soil of this locality and north of us is quite an important factor in the development of better beets in the vicinity of Geneva.

In the second place, I believe there is more sunshine during the growing season in the vicinity of Geneva than there is here in Ithaca. The lack of sunshine here is very noticeable throughout the entire year, but especially in the winter time. It may be, too, that Geneva is far enough north to enable them to have sunshine during a longer daylight period while the beets are growing than at Ithaca.

Thirdly, I think the frequency of rainfall in the two localities is different. There may not be much difference between the total rainfall at the two points, but I think there is some difference, which might have a considerable influence upon the development of the sugar beet, in the frequency of showers in the two localities.

It would, of course, require a special research to discover what part the soil, either physically or chemically considered, played in this problem. The mechanical analyses of the soils and subsoils at Ithaca and Geneva, made by the Bureau of Soils, are given on page 38 of Bulletin No. 78, report of 1902.

It has been several times mentioned that the lack of sunshine data for Geneva was much regretted, but these observations were not obtainable for any point near enough to be of value. The suggestions made as to the effect of sunshine, length of day (Geneva having a day three minutes longer), and distribution of rainfall might work together to explain, at least in a measure, the inferiority of the Ithaca beets, in accordance with the theories developed by the observations and results at other stations, although no relation between sugar content and sunshine data has been established.

IRRIGATED SECTIONS.

These data are at best only preliminary, since they do not cover the whole period of the investigation. The experience of the last twenty years has shown the probability of a very wide extension of the sugar-beet industry on irrigated lands. The desirability of such an extension rests upon an economic basis. In the first place, the control by irrigation of the distribution of water renders the production of a crop practically certain. The other meteorological data are usually of such a constant nature as not to endanger the production of an average crop. The predominating factor, therefore, in so far as yield is concerned, is the distribution of the water. Thus it happens that the crop of beets that will be harvested in the arid regions may be confidently predicted within a few tons. Such a prediction renders all of the farm operations connected with the production of the crop more certain and more economical. In the second place, it is highly important to secure for irrigated areas a crop which shall have a high money value per acre with a reasonable margin of profit. The cost of bringing lands under irrigation as a rule is considerably greater than that of preparing land in the nonirrigated regions for cultivation. The actual cost, therefore, of the land, other things being equal, is greater in the irrigated than in the nonirrigated areas. This higher cost fastens upon the farmer a fixed charge which must always be provided for in the crop before a margin of profit is possible. The ordinary average crops do not always present the most hopeful avenue of securing this increase of profit. For instance, the amount of Indian corn or other cereals or grass crops, with the possible exception of

alfalfa or other species of clover, does not afford the opportunity of certainly discharging the obligation accruing from the interest on the investment in land. The sugar beet, however, adds further inducements in this direction because of the possible and even certain production of an average crop of not less than 15 tons per acre, having a money value delivered at the factory of from $60 to $75. These ideas are fully borne out by the data from the Utah and Colorado stations. The average yield at Logan is 18.9 tons per acre and at Fort Collins 20.4 tons. The average content of sugar in the beet is quite satisfactory at both places, being very good at Fort Collins. The purities are reasonably high, and the data collectively indicate a probable value at the factory of not less than $5 a ton. The yield at the Pomona (Cal.) Station indicates only half a crop, but the quality of the beets as shown by the data is satisfactory.

At all three of the stations where irrigation was employed the average temperature for the growing season is favorable to the production of beets high in sugar. Pomona, with the highest temperature (68.9° F.), being 1.1° below the maximum mean temperature of 70°. It is interesting to compare these stations with Geneva, N. Y., in this respect. The average temperature at Geneva for the six growing months is 64°; at Logan, 62.4°, and at Fort Collins, 59.4°. For the three principal growing months—June, July, and August—the average temperature at Geneva is 69.3°; at Logan, 69.5°, and at Fort Collins, 65.1°. The temperature at Fort Collins is uniformly lower than at the other stations, owing, as is readily seen, largely to its high altitude.

PURITY.

It has been the general observation during this investigation that the purity coefficient always increases with the sugar content of the beet. This general relation is shown very plainly in the tables. Lexington, with the lowest content of sugar, shows the lowest purity, and Geneva, with the highest content of sugar, shows the highest purity. There are, however, irrregularities in the curve representing these data, but these variations only serve to accentuate the general principle illustrated by the data.

PRECIPITATION.

NONIRRIGATED SECTIONS.

A study of the precipitation data for the six growing months shows a close agreement between the nonirrigated stations. The greatest average precipitation during the period observed was at Ames, Iowa, 25 inches. The smallest rainfall is recorded for Lexington, Ky., viz, 14.9 inches. This amount of rainfall is so small as to plainly indicate the chief cause of the small crop produced at that station. At all the

other stations it is seen that the average rainfall is about 20 inches, showing a remarkable uniformity with the exception of Ames and Lexington. The full value of these data can only be determined by studying the distribution of the rainfall in the various annual reports of this investigation. It is evident at once from a study of this kind that the total amount of precipitation for the six months is really greater than the crop required if it could have been distributed evenly and at the proper times. This of course is not possible when dependence is placed upon natural causes alone. In the detailed records discussed in previous bulletins it has been clearly pointed out that the rainfall does not directly, but only incidentally, affect the sugar content of the beet. The great function of the rainfall is related to the magnitude of the crop. Incidentally the rainfall affects the sugar content of the beet in the following way: If the distribution of the rainfall or its deficiency is such as to produce a very small crop made up of small or undersized beets, it exerts the incidental tendency of increasing the percentage of sugar in the beet. A very abundant and well-distributed rainfall by supplying the conditions to grow a beet of extraordinary size will have the opposite effect, of diminishing the percentage of sugar in the beet. If after a period of dry weather during which the beets have matured, as shown by the change in color and the falling of the leaves, there comes a period of warm, wet weather, a second growth will be induced in the beets during which to a certain extent the stored sugar is consumed, with the incidental result that the percentage of sugar in the beet will be diminished. The total changes in percentage composition induced by the rainfall may reach considerable magnitude and may determine whether or not in the process of manufacture favorable economic results will be obtained. Far more important than this effect, however, are the relations of the rainfall to the magnitude of the crop—relations which are well established but which do not form an essential part of this investigation.

IRRIGATED SECTIONS.

The inspection of the table of average precipitation shows that the Fort Collins Station approaches in its average rainfall that of Lexington, Ky., which had the least precipitation of any of the nonirrigated stations. The average precipitation for the six months at Fort Collins is 11 inches, while the average precipitation of Lexington is 14.9 inches. The average precipitation at Logan, Utah, for the six growing months for three years is 5.9 inches. The station at Pomona, Cal., may be regarded as actually arid, since the average precipitation for two years is only 3.7 inches, making it evident that the natural precipitation at this station is a wholly unimportant factor.

CLEAR DAYS AND SUNSHINE.

In the detailed records representing the work of the different years attention has been called to the fact that the active principle of light, in so far as it affects the sugar content of the beet, is not probably the most luminous element. It is apparent, at least to a certain extent, that the diffused light from a cloudy sky has practically the same effect in producing sugar as the direct sunlight. The study of the environment, therefore, in respect of the number of clear days and the hours of sunshine does not show as close a relation to the production of sugar as was expected before the investigation was begun. Of the nonirrigated stations the one showing the largest average number of clear days during the five years is Ames, Iowa, while Ithaca represents the other extreme. Of the irrigated stations Logan shows the largest number of clear days and Fort Collins the smallest.

In respect of percentage of sunshine at the nonirrigated stations the highest figure occurs at Lexington, viz, 71.6 per cent, and the lowest at Blacksburg, 53.7 per cent. At the irrigated stations the highest percentage of sunshine is found at Logan and the lowest at Fort Collins. It is evident, therefore, from a study of these average data, that it is not possible in the present state of our knowledge to find any direct relation between the content of sugar in the beet and the number of clear days and percentage of sunshine.

COMPOSITION OF SOIL AND YIELD PER ACRE.

The data appearing in the accompanying table show that Lafayette, Ind., had the smallest yield and Madison, Wis., the largest yield during the series of four years. The crop both at Lafayette and Lexington must be regarded as abnormally small. The yield at the other stations is satisfactory. It was not the purpose of the present investigation to study the soil as a factor of the environment affecting the yield, but only as affecting the sugar content. It is evident that there is only one method by which such a study could prove of value, viz, the establishment of the experiment under conditions which would eliminate all the varying factors with the exception of the composition of the soils themselves. This ideal method of studying the effect of soil on sugar content is to bring the soils, in sufficient quantity, from the different stations to one station, thus eliminating all disturbing factors of the environment save those due to soil alone. This test was included in the original scheme for these studies, but opportunity to carry it into effect was not presented. Inasmuch as in all instances the distribution of the rainfall has been shown to be one of the dominant factors in determining yield, it is hardly necessary to continue further any comparison of the soil and yield data which were merely incidental to the principal purposes of the investigation.

Summary of yield and soil data for four years, 1901–1904.

Station.	Yield per acre.	Nitrogen.	Soluble in 1.115 HCl.		Soluble in N/200 HCl.	
			Potash.	Phosphoric acid.	Potash.[a]	Phosphoric acid.[a]
	Tons.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Lafayette, Ind.[b]	7.5	0.224	0.48	0.10	0.0069	0.00053
Lexington, Ky.[b]	8.0	[a].187	[a].30	[a].47	.....	.....
Ithaca, N. Y	12.9	[b].144	[b].37	[b].14	[c].0077	[c].00003
Blacksburg, Va.[b]	13.3	.149	.54	.10	.0144	.00005
Agricultural College, Mich.[b]	14.3	.118	.21	.06	.0052	.00036
Washington, D. C	15.2	[b].165	[b].35	.05	[c].0062	[c].00020
Geneva, N. Y.[b]	16.1	[a].125	[a].63	[a].09	.....	.....
Madison, Wis	20.5	.132	.35	.11	.0037	.00056

[a] Average for two years.
[b] Averages for three years except where otherwise noted.
[c] Data for one year.

The data show that any direct effect that soils may have upon the sugar content is that which has already been alluded to in sufficient detail, viz, the soil diminishes the sugar content when there is a tendency to produce an overgrowth due to an excess of plant food, and has a corresponding tendency to increase to a slight extent the sugar in the beet where the amount of plant food is not sufficient to produce a normal growth.

The study of the use of fertilizers and manures in the growth of beets and the effect on the sugar content naturally would be considered in connection with the study of the effect of the soil. Such a use of manures, including what are known as commercial fertilizers, as would produce an extraordinary tonnage would tend to diminish the percentage of sugar in the beet. In addition to this it has been shown that certain kinds of fertilizers and manures are more effective in this direction than others. This is especially true of the nitrogenous fertilizers, both when used in the form of nitric acid and also in organic compounds. This class of fertilizers tends preeminently to produce increased tonnage, to develop abundant leaf and root growth, and as a result to diminish to a slight extent the percentage of sugar in the beet while greatly increasing the tonnage. On the other hand, phosphoric acid, and to a less extent potash, show a tendency to bring the beet to an early maturity, thus checking undue growth and increasing to a slight extent the percentage of sugar in the beet. When, however, we consider the total yield of sugar per acre rather than the actual percentage of sugar in the beet, it is evident that that system of manuring which would produce a very much larger crop will cause an almost corresponding increase in the total sugar produced per acre. The general conclusion from the study of these experiments and similar ones made by other investigators is that the soil and, to a somewhat less extent, the fertilizers and manures have only a limited influence upon the actual content of sugar in the beet, and that influence is incidental rather to the vigor of growth than to any specific action on the sugar content itself.

GRAPHIC REPRESENTATIONS OF DATA FOR FIVE YEARS.

It remains now to consider in the aggregate the graphic representations of the average data collected during the five years' study of this problem. First in this connection will be presented the charts showing graphically the aggregate data in the same order as that in which they were presented in the charts for each year.

Chart No. 4 includes the graphic illustration of the percentage of sugar in the beet, the percentage of sunshine, and the latitude of the station. The stations are arranged in the order of the sweetness of the beets produced. Lexington, Ky., occupies the lowest position in this chart and Geneva, N. Y., the highest. The lines present irregularities and no attempt was made to select certain stations to secure a straight line. The curve representing the latitude in general lies in the same direction as that of the sugar content. In fact, if each of these lines were reduced to a straight line by computation, they would lie almost parallel. The chart shows but little relation between the percentage of sunshine and the sugar content of the beet; in fact, the curve of sunshine is highest at the Lexington station, which is the lowest in sugar content. If only a part of this curve were studied, beginning with the Blacksburg Station, there would be less disagreement between the sunshine curve and the sugar content, but such a study is entirely inadmissible, as it would indicate the utilization of selected data in harmony with a certain theory and the exclusion of data not in harmony therewith. In order to present more clearly the relations of the two principal lines in this chart a special graphic illustration has been made (chart No. 7), including only the five stations which were compared throughout the whole five years of the study. These lines are superimposed as closely as possible in such a way as to transect each other proportionately. This method of illustration presents more clearly the existing relations.

In chart No. 5 a graphic illustration has been made of the average data for five years on the sugar content, purity, temperature, and length of day. Considering first the temperature, it is seen that, although there are extreme variations in some instances, there is nevertheless a distinct and marked relation between the temperature and the sugar content. As the temperature rises the content of sugar falls. The important exception to this rule is shown by the curve for Lafayette. The causes which produced so rich a beet at Lafayette have already been sufficiently discussed and account in a great measure for the variation. It is evident, moreover, that in so complicated a problem as the environment presents for a period of five years it was quite impossible to get a correct solution of all the equations between the different factors. In other words, there are

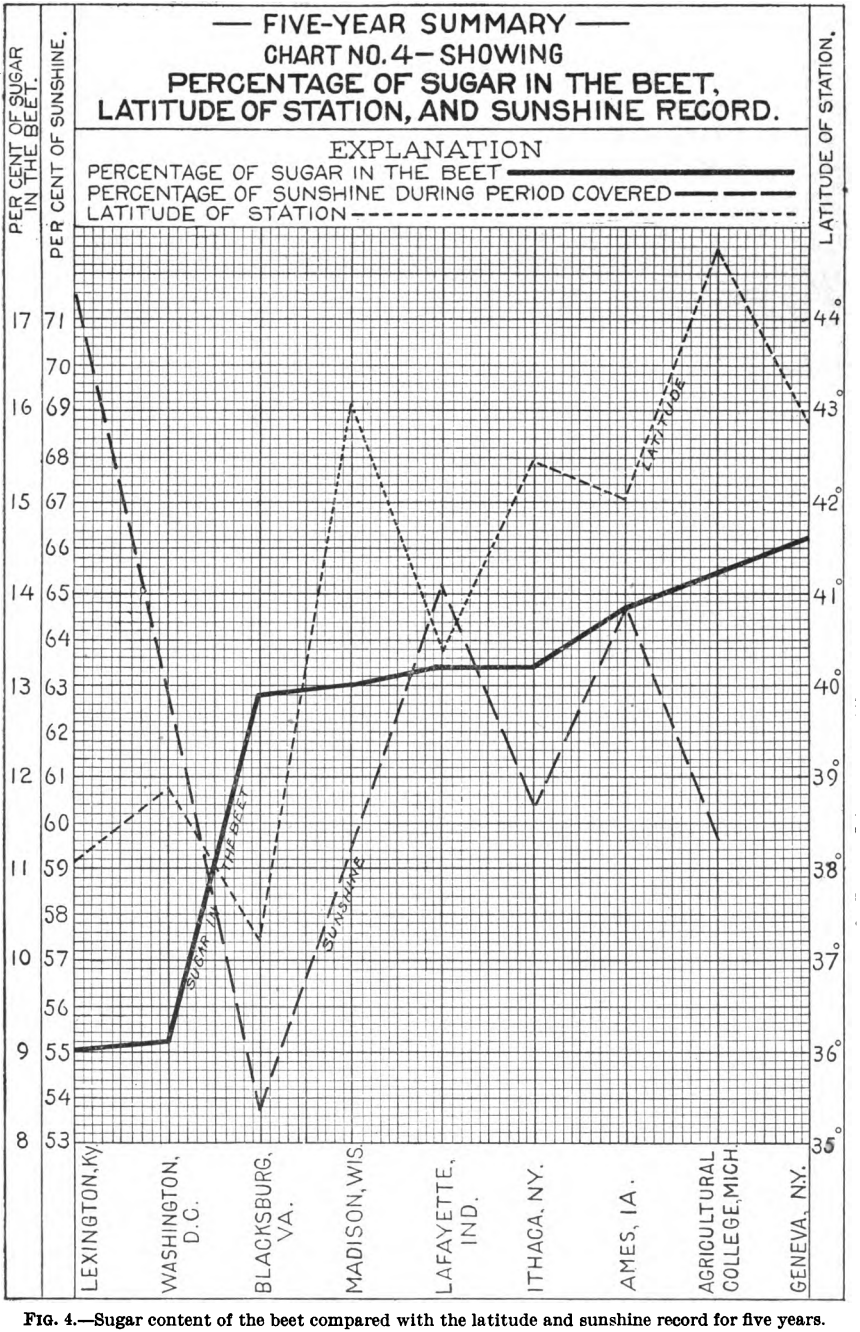

FIG. 4.—Sugar content of the beet compared with the latitude and sunshine record for five years.

more unknown quantities than there are equations with which to determine them. The curve for the length of day shows a very close correspondence, as shown by the graphic chart, to that for the con-

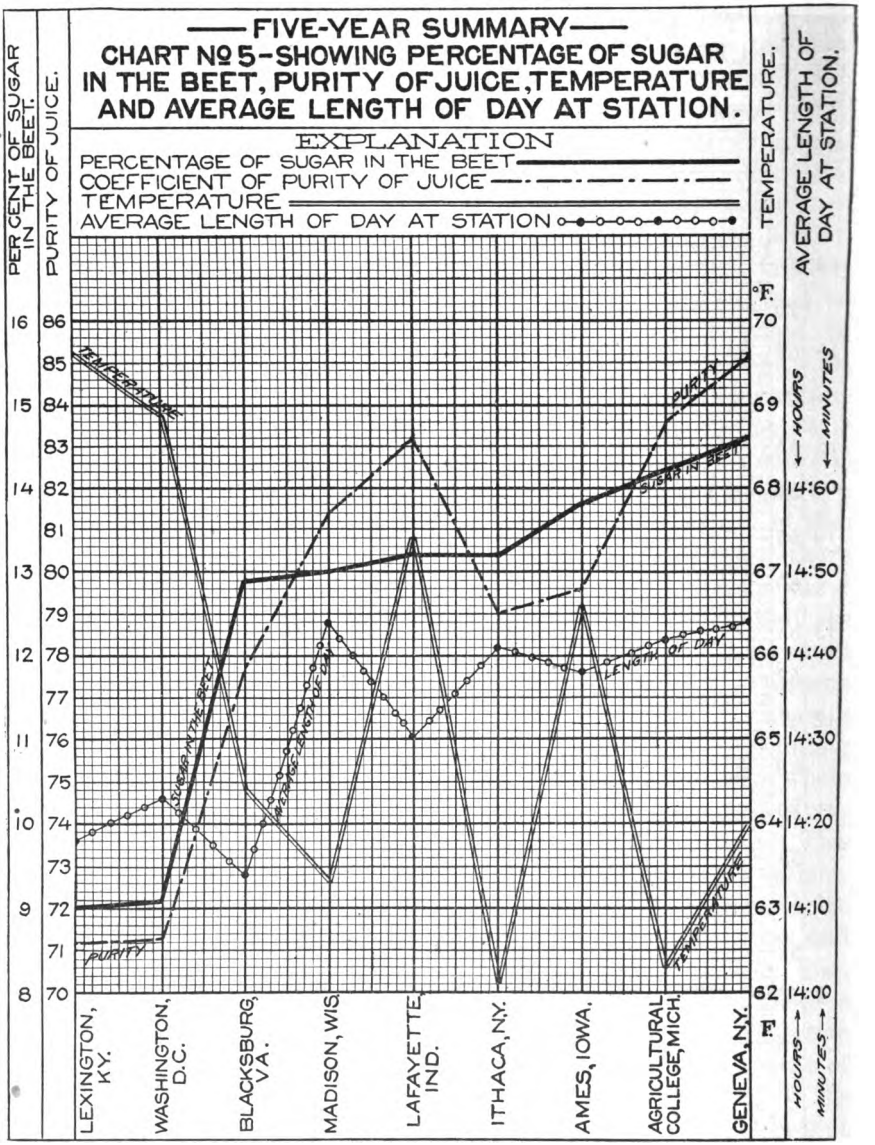

FIG. 5.—Sugar content of the beet compared with the purity of the juice, temperature, and average length of day for five years.

tent of sugar; since the length of day is only a function of the latitude there should be a very close agreement between the two curves. This agreement, however, is displaced by the injection of the factor

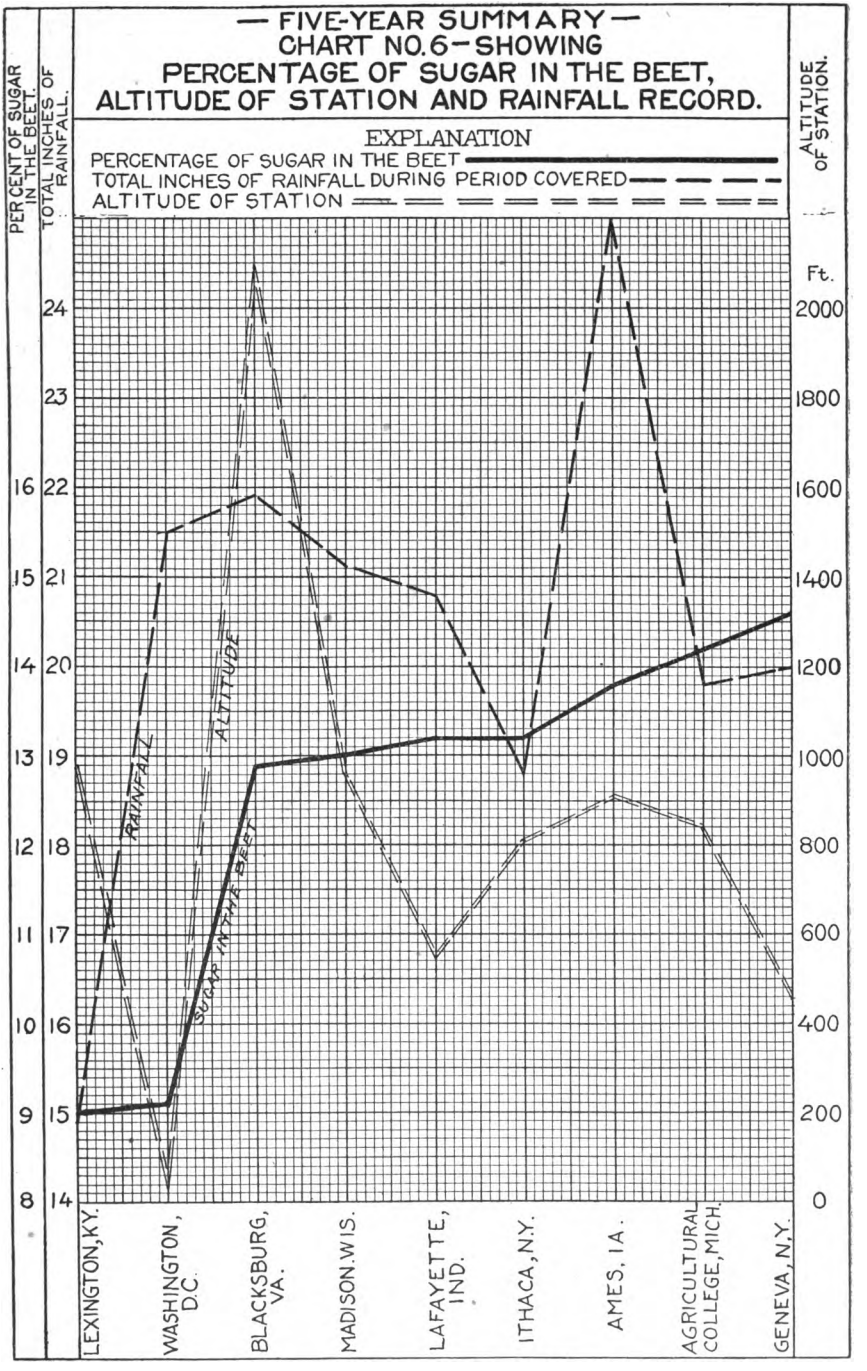

FIG. 6.—Sugar content of the beet compared with the rainfall, and altitude of station for five years.

of altitude into the problem. The altitude affects very materially the sugar content but does not affect the length of day. Any variation, therefore, between these two curves can be very properly accredited to the altitude. By this method of study it may be possible to trace more accurately than could be done otherwise the influence of the altitude upon the sugar content.

The line indicating the purity of the juice for the five years shows in a most convincing manner the effect of the sugar content upon purity; as the sugar content rises the purity increases. This relation is shown more vividly in chart No. 10, where only the sugar content and purity curves for the five stations for the five years are platted.

Chart No. 6 shows the average data for the period of five years on the sugar in the beet, the total rainfall, and the altitude of the station. There is an apparent relationship shown between the sugar content and the total rainfall, but it must be admitted that such a relation is largely fortuitous. The distribution of the rainfall, unfortunately, could not well be graphically illustrated for the five years, and inasmuch as the distribution is quite as important as the total amount of rainfall the two should be considered together for the purpose of reaching any valuable conclusion. The most instructive feature of chart No. 6 is illustrated by the tendency which the high altitude has manifested in compensating for the low latitude in the effect upon the sugar content. To a great degree this is shown in the results at the Blacksburg Station, where an altitude of over 2,100 feet was sufficient to counteract the natural depressing effect of the latitude of the locality, bringing the sugar content of the beet at Blacksburg almost up to a mean position in the whole series. To a minor degree this influence is also shown at Lexington, where the high temperature, higher than that of Washington, combined with a high altitude, higher than that of any other station with the exception of Blacksburg, has tended to raise the sugar content of the beet so that it is only one-tenth of 1 per cent below that at Washington. At the Lexington Station, however, it must not be forgotten that there was another factor, viz, the small size of the beets, which tended to increase the percentage of sugar.

In order to bring the gene al results for the five stations completing the five years work into a more striking comparison, graphic charts have been constructed in which each of the three most important elements of the environment affecting composition is represented separately, and a fourth graphic chart has been added showing only the relations existing between the purity and sugar content. These charts (Nos. 7 to 10) are constructed on the following principles.

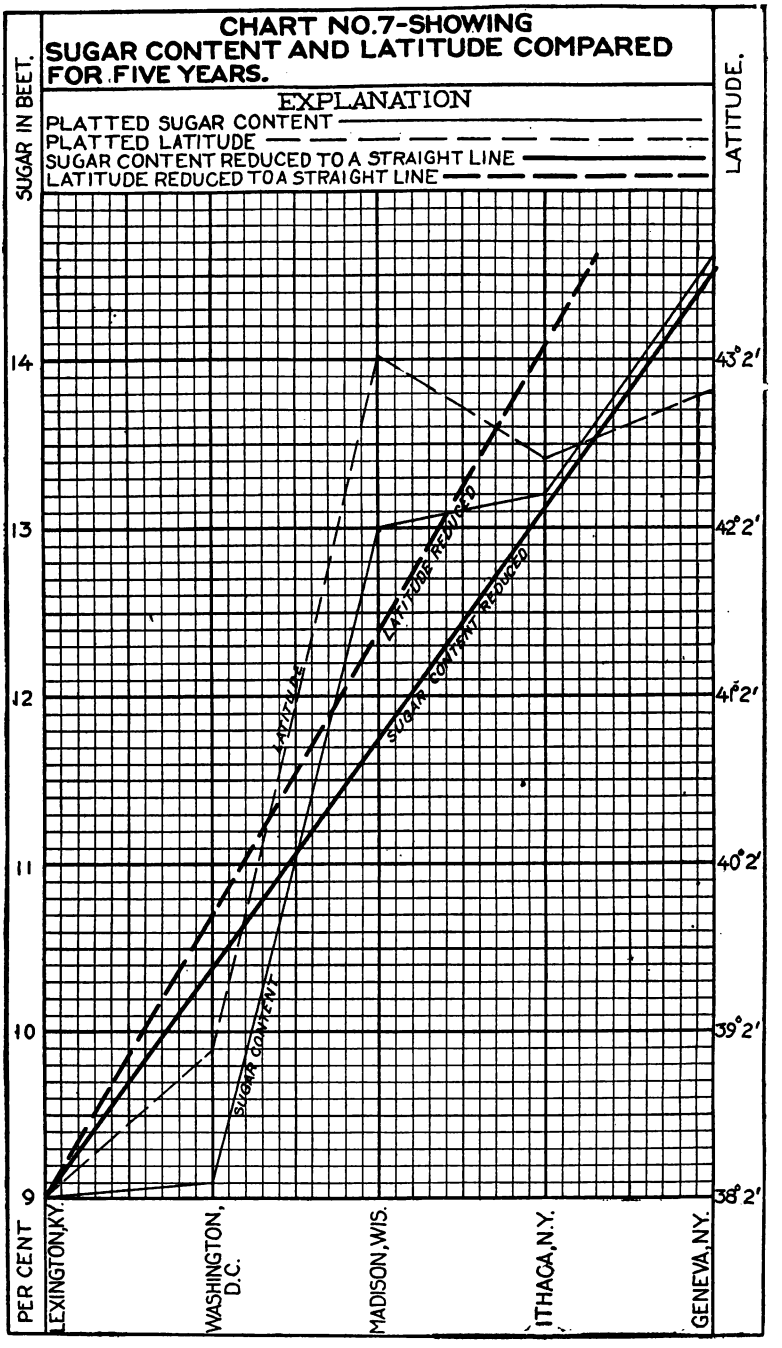

FIG. 7.—Comparison of sugar content and latitude for the five stations completing the entire five years of the experiment.

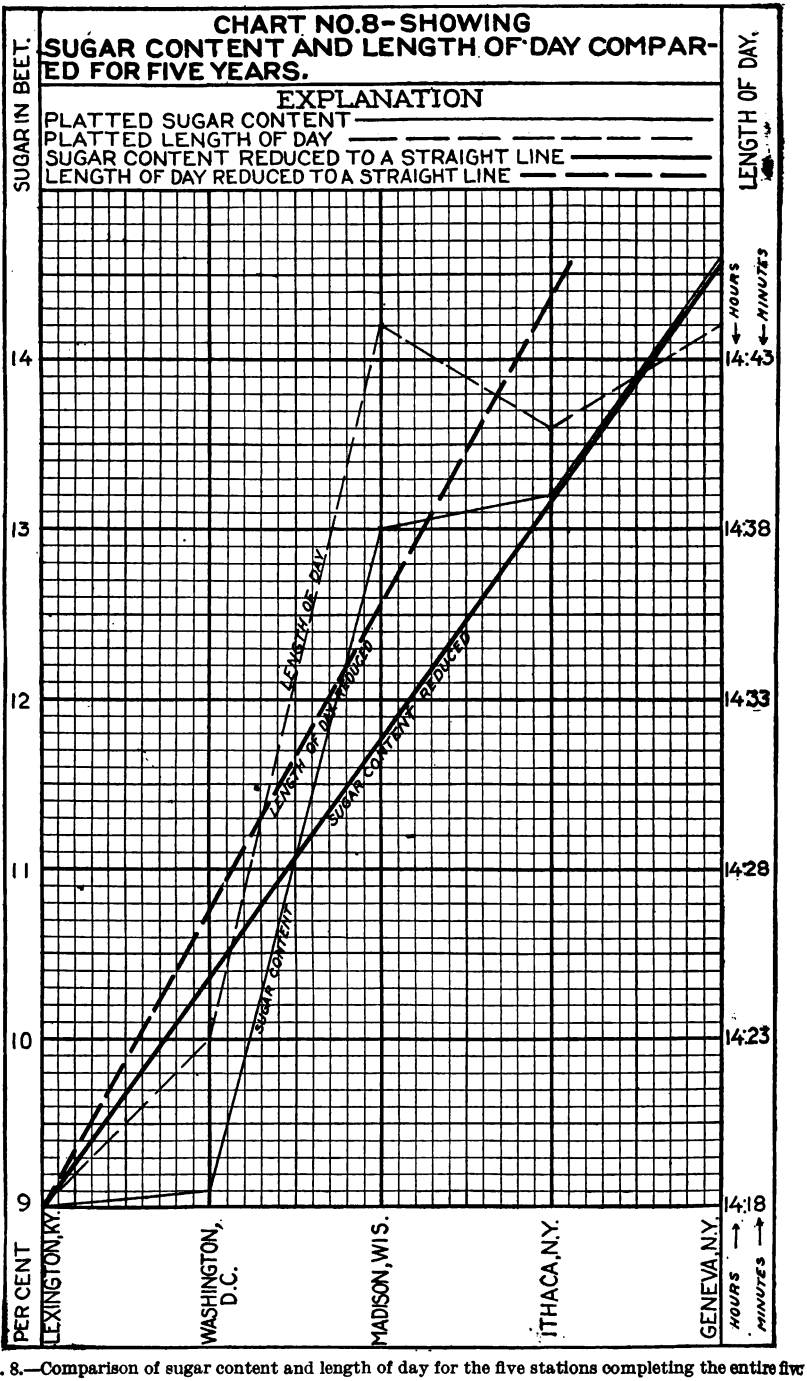

FIG. 8.—Comparison of sugar content and length of day for the five stations completing the entire five years of the experiment.

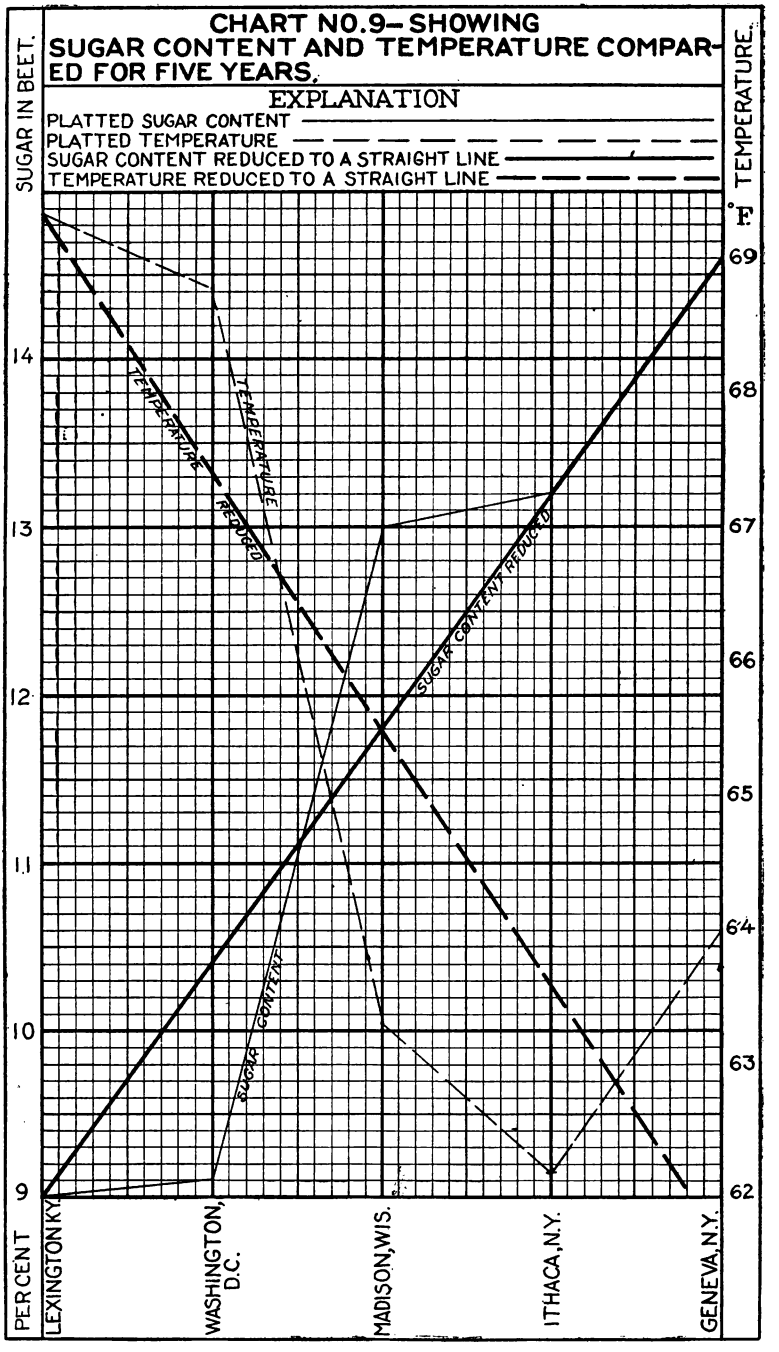

FIG. 9.—Comparison of sugar content and temperature for the five stations completing the entire five years of the experiment.

The basic curve in each of the four charts is the content of sugar at the different stations, which are arranged in order of sugar content. For the purpose of securing a better comparison this curve is reduced to a straight line. The straight line is so placed as to represent as nearly as possible the mean variations of the curve. In other words, an attempt is made to represent in a straight line the total change in the sugar content at the five stations on the supposition that the magnitude of the change was the same for each successive station. On each of the charts there is platted in order one of the four other factors already alluded to, viz, latitude, length of day, temperature, and purity. In each case, however, the curve is platted according to the data collected and the straight line is drawn representing the mean value of the curve. While, of course, it is almost impossible, without the use of elaborate calculations, to exactly place a line of this character, the straight lines on the charts represent approximately the mean values of the curves.

It becomes easy to distinguish at once the general relation which exists between the sugar content and the factor of the environment represented in each case by the straight line drawn as above described. Any detailed description of these final graphic charts is unnecessary, as a glance at the st aight lines of each chart shows the intimate relations existing between the sugar content and the other factors mentioned. In the case of latitude and length of day, the two straight lines having the same origin diverge only slightly from that representing sugar content, and the straight lines for purity and sugar content run still more closely together. The platted and the computed lines for sugar content coincide on Charts 9 and 10 between the points representing Ithaca and Geneva. In the chart representing the relation of the temperature to sugar content it is seen that the straight lines make almost a perfect X. These final graphic charts represent, therefore, in the simplest form of expression, the relations which have been established by the studies conducted throughout a period of five years.

We have now reached the end of this long and laborious research, and while there are many points in connection with the influence of environment which are not clearly brought out, it is believed that the major factors have been determined with considerable accuracy in regard to their influence on the composition of the beet.

The great extent of our country affords exceptional facilities for studying the effect of environment in widely separated localities. In former studies by this Bureau the chemical composition of cereals[a]

[a] U. S. Dept. Agr., Division of Chemistry, Richardson, Bul. No. 1, An investigation of the composition of American wheat and corn, 1873; Bul. No. 4, ibid., 1884: Bul. No. 9, Third report on the chemical composition and physical properties of American cereals, wheat, oats barley, and rye, 1886.

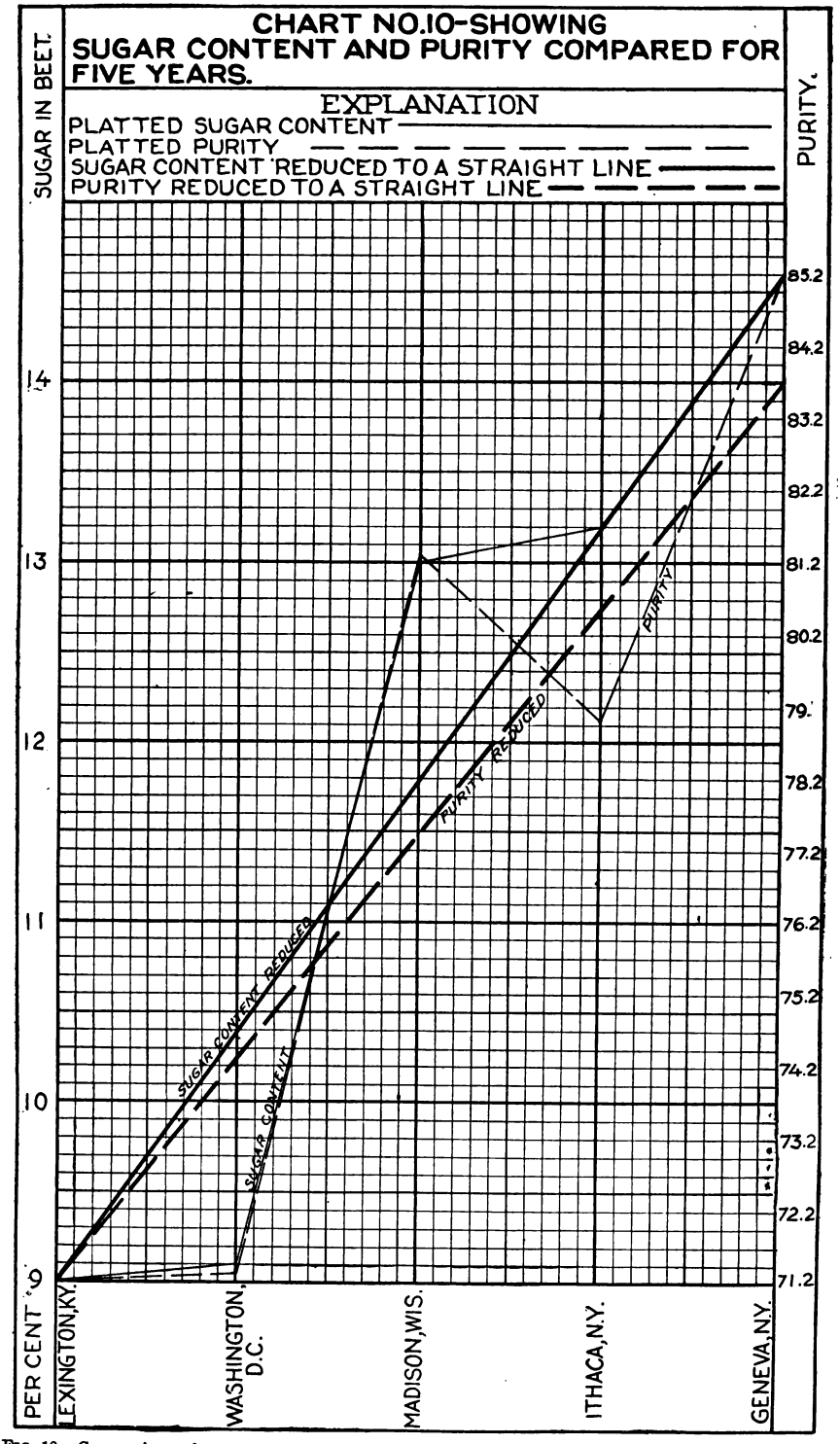

FIG. 10.—Comparison of sugar content and purity at the five stations completing the entire five years of the experiment.

was carefully studied in one or two localities without, however, extending the principle of the investigation to the extent to which it has been applied in these studies. The composition of the sorghum plant[a] also was studied throughout a series of years, but without the application of the principle of widely separated areas under the various conditions of the environment. The value of the present investigations, of course, must be judged by the data submitted, lacking as they are in many points which would lead to more definite conclusions. It appears, however, that one of the principal values of the investigation consists in marking out in a preliminary way the general principles on which such studies should be based. Larger experience and more extended investigations will serve not only to perfect the plan of operations but also to vastly increase our knowledge of the effect of environment upon the composition of plants.

[a] U. S. Dept. Agr., Division of Chemistry Bul. No. 40, Records of experiments with sorghum, 1893.